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ANNALS of SURGERY

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No. 2

MASSIVE (ATELECTATIC) COLLAPSE OF THE LUNG*†

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Definition and Description.—Massive collapse of the lung is a condition in which one or more lobes, previously well aerated, suddenly, without apparent cause, lose their air content and collapse. Sir John Rose Bradford¹ has defined the condition as "an unusual condition in which the lung, without the presence of any gross lesion, such as bronchial obstruction, pleural effusion, etc., interfering with the free entry of air, becomes airless to a greater or less degree." This condition is essentially an atelectasis and should not be confused with collapse of the lung incidental to pneumothorax; the two conditions have nothing in common.

In massive (atelectatic) collapse, the lung does not leave the chest wall. In its collapsed or atelectatic state the lung occupies a smaller space than it did when fully expanded. To compensate for the space lost from collapse of the lung, the chest wall is depressed, the trachea, heart and mediastinal structures are drawn over toward the involved side and the diaphragm is pulled upward. The loss of air content produces consolidation of the lung fully as dense as that of lobar pneumonia.

Radiographic Characteristics.—The radiographic picture produced is most striking and quite characteristic. One entire side of the chest shows a dense, homogeneous consolidation. There is a definite narrowing of the chest cavity on the involved side, the ribs become more oblique and there is a decrease of the intercostal spaces. The trachea, heart and other mediastinal structures are displaced toward the involved side; the tracheal displacement is always evident; the heart may show varying degrees of displacement, ranging from slight to the extreme of being undetectable in the radiograph. The apex beat, normally present in the *left* mammillary line may be displaced to a position in the *right* mammillary line. Where the upper lobe alone is involved, displacement of the heart may be negligible and deviation of the trachea the only sign. Compensatory emphysema of the uninvolved side may be very marked.

Physical Signs.—The physical signs associated with this condition after collapse is well established are likewise very striking. Inspection reveals a flattening and immobilization of one side of the chest. The respiratory function is carried on entirely by the other lung. The percussion note is flat over

* Read before the Second International Congress of Radiology, Stockholm, Sweden, July 23-28, 1928.

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the entire side and auscultation fails to elicit normal vesicular breathing. The marked displacement of the trachea may give an erroneous impression of pneumonic consolidation.

During the preatelectatic state crepitant and sibilant râles may be heard over the collapsing lung. This was observed in Cases IV and VI of our series, but its significance was not understood at the time. Scott and Joelson² refer to such findings but over both lung fields.

The condition is most frequently encountered as a *post-operative complication of abdominal and rectal surgical procedures, especially following appendectomy and herniotomy*. Its occurrence is apparently independent of the anæsthetic used, cases being reported following all types of anæsthesia, even spinal anæsthesia, or when local anæsthesia was used. It occurs after fracture of the pelvis, or of the femur, and after injuries apparently trivial to the chest, abdomen or buttocks. The condition may result from post-diphtheritic paralysis of the diaphragm, or from diphtheria, poliomyelitis, or meningitis. It is usually unilateral, occurring most frequently on the same side as the trauma or operation. Numerous cases of contralateral involvement are reported (our Case III is an example). Two instances of bilateral atelectasis have been reported, one by Bergamini and Shepard³ following operation for uterine fibroid, and death occurred on the operating table. Autopsy revealed total atelectasis of both lungs. The second case was reported by Santee,⁴ as having followed septic abortion and apparently occurred in a physician's office.

Review of the Literature.—This condition is by no means a recent observation. It was first reported as a definite clinical entity in 1890 by W. Pasteur,⁵ who described it as "massive collapse of the lung." His first observations were on thirty-four cases of post-diphtheritic paralysis of the diaphragm. In the Bradshaw Lecture⁶ in 1908, he discussed the nature of massive collapse of the lung as contrasted with the scattered lobular collapse that may occur when the bronchioles are obstructed by secretions, and the alveoli slowly emptied by absorption of their air into the circulating blood. He considered the cause of the collapse as due to paralysis of the diaphragm and other respiratory muscles, and suggested that reflex inhibition of the diaphragm might lead to similar results.

In 1914, he⁷ again called attention to the condition as a post-operative complication of abdominal cases, reporting sixteen such cases which had been encountered in two thousand abdominal operations. He also stated that he had seen a similar condition after injuries to the chest wall. The pathology in every instance was the same.

"Whenever—whether as a result of paralysis or of reflex inhibition of muscular action—the distending force acting on the lungs becomes less than that of the elastic and muscular agencies which tend to cause its contraction, the latter, so to speak, take charge with the result that the affected portion of the lung rapidly empties itself of its contained air."

The disturbance in the respiratory function may be due either to paralysis or reflex inhibition from inflammation or pain.

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In the same year, Elliott and Dingley⁸ reported eleven cases all of which had followed abdominal operations. After a complete analysis of their cases, these writers came to the conclusion that immobilization of the diaphragm and shallow respiratory movements allowed the bronchioles to become blocked with secretions, the circulating blood absorbing the residual alveolar air. They observed large amounts of mucopurulent sputum in all of their cases and concluded that atelectasis was a direct result of occlusion of the bronchi by this means.

Holmes⁹ cites four cases and refers to twelve others found by Bradshaw among 3,559 patients operated upon at the Middlesex Hospital from 1906 to 1910. These cases all developed among post-operative patients, especially after appendectomy and herniotomy.

Crymble¹⁰ reported fifteen cases after gunshot wounds which did not vary essentially from those resulting from abdominal operation.

In 1918 to 1920, Sir John Rose Bradford¹ made a complete study of the subject in connection with war wounds. He failed to find any postmortem evidence of bronchial obstruction, pleural effusion or other lesion which might interfere with the aeration of the lung, and concluded that, while it seemed incredible, the evidence would seem to indicate that a reflex spasm of the bronchioles was the cause of the obstruction. The condition was observed by him following injuries of the chest and trunk, after fractures of the pelvis or femur, and after gunshot wounds of the chest. He cites an instance where an apparently trivial wound of one side of the chest was followed by a collapse of the opposite lung, no anæsthetic having been administered, and no operative interference undertaken. Some injury, however, seemed to be present in all cases.

Briscoe,¹¹ in 1920, analyzed the possible causes of massive collapse and concluded that it was produced "by the onset of inflammation affecting the muscles of the crus of the diaphragm, situated behind the peritoneum; one-half of the diaphragm and its synergistic and antagonistic muscles are out of action owing to inflammation of the muscle or the pleural membrane covering it."

In 1921, Scrimger¹² reported seven post-operative cases among 540 abdominal and rectal operations; six followed herniotomy or appendectomy, one followed hemorrhoidectomy.

In 1922, Elwyn and Girsdansky¹³ reported an instance of massive collapse after a laparotomy for penetrating stab wound of the abdomen. In the same year, Hirschboeck¹⁴ reported three cases following abdominal operations which showed no variation from those already described in the literature. Cutler and Hunt¹⁵ in this year also made a very painstaking study of post-operative pulmonary complications. They mention massive collapse as a possibility but assert that it never has been observed in their experience.

Regan,¹⁶ in 1924, reported a case of collapse of the lung following poliomyelitis. In the same year, Ritvo¹⁷ reported an additional case and presented a very complete study of the subject, with special emphasis on the radiological manifestations of the disease.

Early in 1925 Scott¹⁸ published a complete study of all reported cases. Aside from war wounds (Barling and Morrison^{19,20}), he found sixty-four cases in the literature, only thirty-six of which were given in sufficient detail for analysis. To these he added four cases of his own observation, all occurring as post-operative manifestations, showing little variation from those previously described. Toward the end of the same year, Chevalier G. Jackson and Walter E. Lee²¹ showed the relationship between lobar atelectasis and obstruction of the bronchi by foreign bodies or secretion.

In 1926 and 1927, the writer²² reported five cases each presenting some unusual feature. These will be discussed in greater detail later on in this communication. During 1926, additional cases were reported and the subject discussed from various angles by Mason,²³ Junghagen,²⁴ Trout and Hoyter,²⁵ Eades,²⁶ and Beals.²⁷ None of these reports, however, served to throw any light on the etiology.

In 1927, Bergamini and Shepard³ reported two cases of bilateral atelectasis which resulted in death. Both came on immediately following operation. One was in a woman who was operated for fibroid. She was in good condition before operation but died on

the table, autopsy revealing bilateral atelectasis. The second case followed septic abortion. Santee⁶ reported a similar case.

Scott and Joelson⁷ call attention to the influence of posture on the development of massive collapse and cite a very remarkable case in which on two separate occasions the same individual was operated for kidney stones on either side and suffered massive atelectatic collapse of the *opposite lung on each occasion*. They cite numerous other instances where the position of the patient may have been a definite factor in producing the collapse. Churchill and Holmes^{28, 29} stress the theory that "collapse is the result of a combination of obstruction of the bronchioles by inflammatory oedema and secretion and reflex immobility of the diaphragm." Churchill asserts that bronchial obstruction is essential to collapse. Hearn and Clerf³⁰ demonstrate progressive reinflation after repeated bronchoscopic examination and removal of mucus. Additional reports and discussions in 1927 were made by Benedetti,³¹ D. Y. and J. P. Keith and Bell,³² Solem,³³ Mastics, Spittler and McNamee,³⁴ Asper,³⁵ Campbell,³⁶ Diez,³⁷ Garrett,³⁸ McKinney and Porter,³⁹ Kletz,⁴⁰ Brennemann,⁴¹ Leopold,⁴² F. J. Smith and Davidson,⁴³ Peppard,⁴⁴ Scholty,⁴⁵ Tidy and Phillips,⁴⁶ Carlson and Luckhardt,⁴⁷ Harrington,⁴⁸ and Lewd and Rityo.⁴⁹

TWO GENERAL TYPES OF INVOLVEMENT

From a consideration of the reported cases it will be found that the disease manifests itself in two more or less well-defined forms: one in which the symptoms of respiratory distress predominate, the other in which any respiratory phenomena are entirely overshadowed by other manifestations. In the first type, the onset is usually quite sudden, within one to four days after operation or trauma, with pain in the chest, dyspnoea and rapid pulse. The patient may even become cyanotic. The temperature, usually normal at first, later acquires an irregular character, ranging from 98.6° to as high as 102.5° or 103° F., within a few hours. After a few days a cough develops and there may be a small amount of mucopurulent sputum. The development of the fever seems to run parallel to the quantity and character of expectoration. The sputum is never bloody or of the "prune juice" type. The white blood count is somewhat higher than normal, advancing steadily, and with the appearance of mucopurulent sputum reaches as high as 20,000 per cmm.

In the second type the pulmonary symptoms, as has been said, are entirely secondary to other symptoms—either an exciting trauma or operation, or some pain in a distant part. There is no pain in the chest and little if any embarrassment of the respiration or change in the pulse rate. Although the cough, fever and leucocytosis may subsequently develop, they are usually attributed to the inciting condition. In such cases the chest condition is usually discovered incidentally during physical or radiographic examination.

Regardless of the type of involvement, the duration is usually from one to three weeks. The condition may terminate rapidly by a sudden reinflation, and reestablishment of the respiratory function or may require several weeks for complete recovery. When sudden reinflation occurs, the reexpansion of the lung can be detected immediately in the radiograph, the lung field taking on a normal appearance in a few minutes. The slower method shows an irregular reestablishment of the respiratory function by successive aeration of small patches of lung tissue, complete reinflation requiring several days or weeks.

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Pathology.—Very few autopsies are recorded from which the true character of the pathology involved in the condition can be determined.

Pasteur⁸ recorded eight autopsies in which massive collapse of the lung followed diphtheritic paralysis of the diaphragm, in five of which massive atelectasis was demonstrated. He was unable to find any bronchial obstruction which could account for the condition in any instance. In every case he noted a thick fibrinous exudate over the diaphragmatic surface and pleura. Bradford,¹ Briscoe,¹¹ Bergamini and Shepard,⁸ Santee⁴ and others have made similar autopsy observations in cases which followed war wounds and operations.

Bradford failed to reveal any evidence of "gross lesion such as bronchial obstruction, pleural effusion, etc., interfering with the free entry of air . . ." Elliott and Dingley⁸ emphasize the presence of a large amount of mucopurulent secretion in the bronchioles.

Bergamini and Shepard failed to find any evidence of obstruction. "Gross examination of the collapsed lung gave no evidence of bronchial obstruction. There were no gross particles in the bronchi. Neither was there any of the mucopurulent secretion so strongly emphasized by Elliott and Dingley and by Churchill as a probable etiological factor. Uniform dilatation and engorgement of the capillaries, arterioles and venules strongly suggest probable vasomotor disturbance."

Santee records similar findings.

Briscoe found a thick fibrinous exudate over the pleura and diaphragm similar to the findings recorded by Pasteur.

Microscopic section of specimens in all instances showed extensive atelectasis, but in each instance a few rounded globules of air remained.

Case I of our series was autopsied disclosing the same general condition. A similar exudate covered the pleura, and microscopic examination of the lung tissue showed atelectasis without cellular reaction. On opening the pleural cavity the chest wall resumed its normal contour and the lung did not fill the chest cavity.

CASES OBSERVED BY THE WRITER

Six cases have come under my own observation. These I describe, not only on account of the rarity of the condition, but also because each case has certain features which are somewhat unusual. Of these the first five have been previously reported in the *Jour. Amer. Med. Assn.*, vol. lxxxviii, p. 1539.²²

CASE VI is here presented for the first time and is unique in that it represents a complete radiographic record of this condition from the time of injury, throughout the developing collapse, to complete subsequent inflation. This case occurred on the service of Doctor Cole, to whom I am indebted for this report. A. G., white, male, aged twenty, was admitted to the hospital at 4:45 A.M., on January 18, 1928, shortly after the automobile which he was driving had been struck by a railroad train. Physical examination disclosed multiple abrasions, contusions and lacerations of the scalp, body and extremities. X-ray examination revealed the twelfth rib on the right side completely pulled from its spinal attachment and displaced about an inch to the side. (Fig. 1.) There was no evidence of other injury to the skull, spine or chest, no evidence of a hollow viscus (no free air in the abdomen) and the diaphragms were in normal position. Shortly after admission, the patient passed blood in the urine. On admission, temperature was 98.4° F., pulse rate 112, respirations 24 per minute, blood pressure 115/55, white blood cells, 7,000.

On the afternoon of the same day (January 18), radiographic examination of the chest was made (Fig. 2). In the few hours intervening between these examinations, the right diaphragm had become elevated, and was immobile; there was also an irregular accentuation of the lung markings throughout the right chest. Physical examination made the morning of January 19 (scarcely more than twenty-four hours after the injury),

revealed a flat percussion note over the entire right chest. Radiographic examination on January 20, showed a typical picture of massive collapse of the lung (Fig. 3). During the night, the pulse rate reached 140 per minute and the respirations were as frequent as 40 per minute. Within a few hours these dropped to a pulse rate of 88 and respiration rate of 20. Further radiographic examination, made January 23, revealed almost complete reëxpansion with only a very small atelectatic area remaining in the lung (Fig. 4). No therapeutic measures were attempted, other than the ordinary rolling about in bed.

The points of interest in this case were:

(1) The complete record afforded by examination within a few hours after injury, showing the diaphragmatic position normal, (2) the radiographic record in the films taken within ten hours after injury, showing the beginning of collapse, (3) the evidence of complete collapse within twenty-four hours after injury, and (4) the spontaneous reëxpansion.

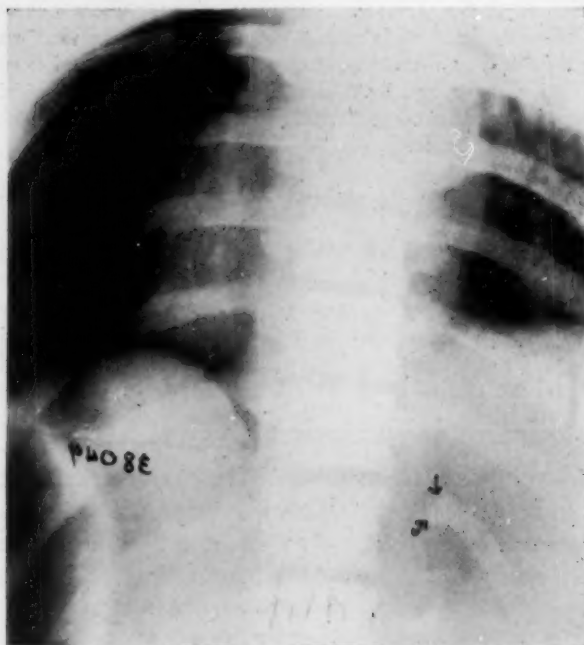


FIG. 1.—Case VI. Patient was struck by a train a few hours before, which resulted in complete severance of the twelfth rib from its spinal attachment. The urine contained blood showing injury to the kidney on this side. Film taken at that time showed normal position of the diaphragms.

ETIOLOGICAL THEORIES

From a consideration of all reported cases, four hypotheses have been advanced as possible explanations of the cause of this condition:

1. The paralytic theory, that the collapse of the lung is due to pressure exerted by the collapsed chest wall and elevated diaphragm, resulting in turn from paralysis of these structures. That the resulting sluggishness of respiration permitted collection of secretion in

bronchioles which caused this obstruction, and that the air remaining in the alveoli of the obstructed area was absorbed by the circulating blood. In other words, the pressure of the chest wall and diaphragm is considered primary, the lung collapse, secondary. (Supported especially by Pasteur.)

2. The diaphragmatic infection theory, "that due to the onset of inflammation affecting the muscles of the crus situated behind the peritoneum, one-half of the diaphragm and its synergistic and antagonistic muscles are out of action, owing to inflammation of the muscle or the pleural membrane covering it." This results in a disturbance of the respiratory function which in turn leads to collapse. (The view held by Briscoe.)

3. The spasmodic reflex theory, that some spasmodic reflex of the bron-

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chioles causes them to become occluded, permitting the subsequent absorption of air in the segment of the lung involved. (Explanation advanced by Sir John R. Bradford.)

4. The simple obstruction theory, that obstruction of the bronchioles by secretions is the entire explanation, such a condition being all that is necessary for the development of the other features of the condition, and any disturbance of the respiratory function, purely incidental. (Observations of Jackson and Lee.)

5. The angioneurotic theory, that the rapidity of development of the condition in certain instances and the dilatation of the capillaries and engorgement of the blood-vessels lend credence to this theory, according to Bergamini and Shepard. Both Gwyn⁴⁵ and Scott also mention this possibility.

6. The posture theory, that the position assumed by the patient during post-operative convalescence may favor the production of this condition. This view is held by Scott and Joelson.

7. The theory of combined obstruction and impaired respiration, that "collapse is the result of a combination of obstruction of the bronchioles by inflammatory cedema and secretion, and reflex immobility of the diaphragm," the view held by Churchill, and also mentioned in substance by Elliott and Dingley.



FIG. 2.—Case VI. Twelve hours later, elevation and immobilization of the diaphragm was noted, and a definite haziness and accentuation of the lung markings over the right lung. The process was evidently going on at this time.

DISCUSSION BASED ON CLINICAL OBSERVATIONS, PATHOLOGICAL FINDINGS AND EXPERIMENTAL EVIDENCE

The original contention of Pasteur that this atelectatic condition was due to the pressure of the depressed chest wall which resulted from paralysis of the diaphragm and other respiratory muscles, is not borne out by the facts. In patients suffering from tuberculosis, in whom one of the phrenic nerves has been sectioned as a therapeutic measure, this condition has never resulted; consequently some other factor must have been a contributing cause in Pasteur's original cases. Elliott and Dingley performed experiments on rabbits, sectioning the phrenic nerve and other nerves influencing respiration and never witnessed this phenomenon. Briscoe likewise performed section of the phrenic

nerve with similar results, while Coryllos and Birnbaum⁴⁶ failed to produce the condition after phrenicotomy.

At the autopsy of our first patient, on opening the chest cavity, the chest wall assumed its normal contour and the lungs failed to fill the entire cavity. This would indicate that the depression of the chest wall was secondary to lung collapse and not the primary factor in producing this lung condition. In Case V of our series also, where atelectasis was associated with pneumothorax, the chest wall was never retracted. Elkin⁴⁷ measured the intrathoracic pressure in patients suffering with massive collapse and found the negative intrapleural pressure increased. Normally the intrapleural pressure varies from

—9 mm. Hg. on inspiration to —2 mm. Hg. on expiration.⁴⁸ In the three cases cited by Elkin, the negative pressure was more pronounced in both chest cavities. The greatest variation noted was —12 mm. Hg. on inspiration and —15 mm. Hg. on expiration on the involved side; —6 mm. Hg. on inspiration and —8 mm. Hg. on expiration on the uninvolved side. In the röntgenographic observations made in Cases I and VI, there was retraction of the trachea before definite indications of collapse of the lung or sinking in of the chest wall. In Case V, where spontaneous pneumotho-

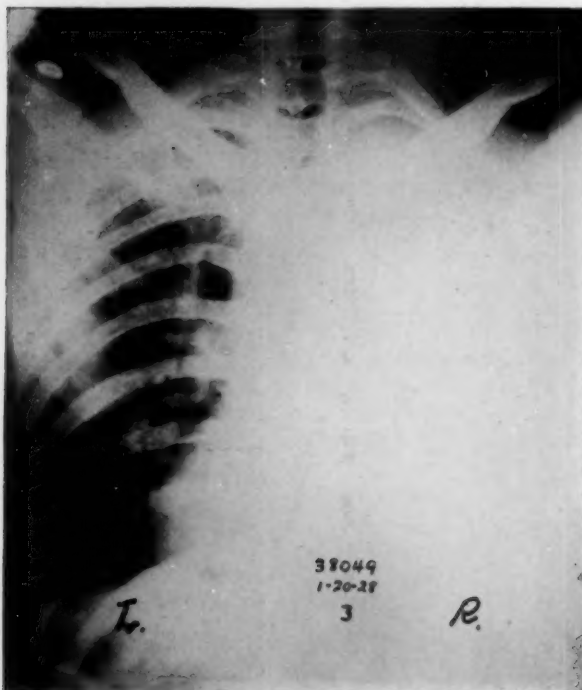


FIG. 3.—Case VI. Twenty-four hours after injury there was complete atelectatic collapse of the right lung.

rax occurred in association with massive atelectatic collapse, the chest wall did not become sunken and there was little if any displacement of the walls of the pleural cavity. We must conclude, therefore, that massive collapse of the lungs does not occur solely as a result of paralysis of the diaphragm or other respiratory muscles, nor from pressure of the chest wall.

Briscoe's supposition that collapse is produced by a lack of synchronism between the diaphragmatic movements brought about by retroperitoneal infection of the crus of one or other diaphragm, cannot be upheld because at best it would explain abdominal cases only, and post-operative cases in which there had been infection. Many cases have been cited where the condition came on so quickly after trauma (gunshot wound) that infection would be impossible.

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The cases reported by Bergamini and Shepard and by Santee in which collapse occurred during operation, would rule out infection as an indispensable cause. In Cases II and VI of our series, also, collapse followed so soon after injury as to make infection impossible. Briscoe's basis for this assumption of infection as a cause lies in the detection at autopsy of a thick fibrinous exudate over the pleura and diaphragm. A similar exudate was noted by Pasteur in his autopsies of post-diphtheritic patients, and in the autopsy which was performed in Case I of our series this finding was also confirmed. In all of these cases, however, a previous infection had been established. No evidence of such an exudate was present in any of our cases in which sudden complete re-inflation occurred. Complete, rapid re-inflation was noted in Cases II, III, IV and VI and in none of these was there evidence of such an exudate. Re-inflation was so rapid that there would have been no time for the absorption of an exudate had it been present. The autopsy reports of Bergamini and Shepard and of Santee on their cases do not mention this finding.

We must conclude, therefore, that surely, in many cases, infection of the diaphragm plays no part in the production of collapse and that in such cases where a thick, pleural exudate does form over the diaphragm and pleura, it is rather the result of inactivity of the diaphragm than the cause of any interference with its motion. In every case reported in the literature, the appearance of an exudate is in association with an established infection.

The theory advanced by Bradford, that collapse of the lung is brought about by a reflex stimulation of the constrictor nerve fibres to the muscles of the bronchioles, remains still to be considered. Ample experimental evidence is found of the existence of constrictor nerves and muscle fibres on the bronchioles sufficiently strong to produce complete and prolonged constriction (Longet⁴⁹; Auer and Lewis⁵⁰). That such constriction ever results in atelectasis, however, has never been proven. The frequency with which the condition follows abdominal operation would lead one to suspect that an insult to

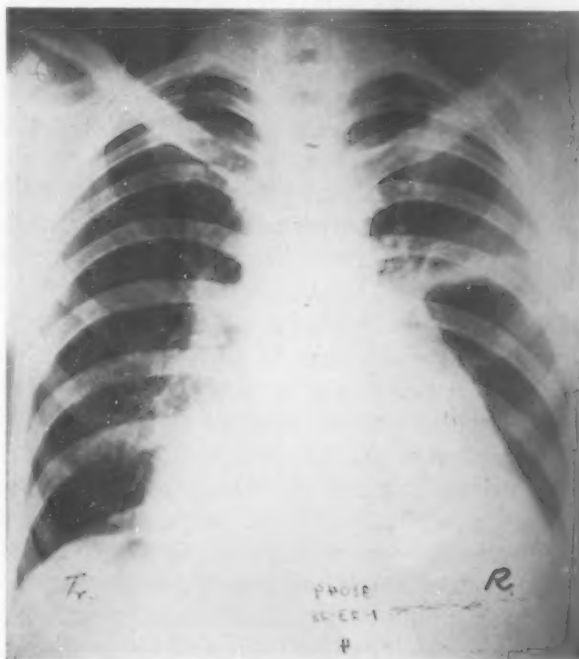


FIG. 4.—Case VI. Showing appearance after reestablishment of function. Spontaneous re-inflation occurred in this case.

the vagus nerve might offer the reflex stimulus for this occurrence. Briscoe, however, performed numerous experiments in which in an attempt to produce this reflex spasm he irritated the peritoneum, stimulated the vagus, etc., all without results. There is, therefore, no direct evidence in support of the view that reflex *bronchial spasm* is the cause of the disease, although there is evidence to indicate that *contractions of the bronchial musculature* may be sufficiently powerful to shut off the bronchi.

Bronchial obstruction by secretion alone is the cause suggested by Jackson and Lee. Long before the discovery of this condition it had been observed that when a foreign body completely occluded a bronchus, the portion of the lung supplied by the obstructed bronchus became atelectatic. Mendelssohn⁵¹ in 1845, and in the following year, Traube,⁵² produced atelectasis by occluding the bronchi with paper wads, shot and acacia. Lichtheim⁵³ in 1879, found that introduction of a stick of laminaria into a bronchus of a rabbit caused atelectasis of its lung segment within a few hours, provided the circulation of the blood was left intact. If the blood-vessels to this section of the lung were ligated simultaneously with the obstruction of the bronchus, the air remained in the obstructed lung and atelectasis did not ensue. From this it was concluded that the residual air is rapidly absorbed by the circulation. Similar observations by Chevalier Jackson and his co-workers on foreign-body atelectasis in human beings, has resulted in the same conclusions. Clinicians (Golden⁵⁴; Chizzola⁵⁵) have observed that bronchial tumors, when they completely obstruct, produce within a very short time a complete atelectasis of the segment of the lung supplied by the bronchus.

Partial obstruction results in emphysema. Since the diameter of a bronchus is smallest during expiration, obstruction first occurs during this phase of respiration; the air which is drawn in during inspiration cannot subsequently be expired and remains trapped. This phenomenon is the basis of Manges's⁵⁶ diagnostic sign for non-opaque foreign bodies in the lung. Obstructive emphysema is caused by the partial obstruction of a bronchus. The excellent experimental work of Coryllos and Birnbaum in which a bronchus was obstructed to varying degrees by inflation of balloons introduced through a bronchoscope, serves to confirm these previous observations and to establish beyond a doubt the relationship between complete bronchial obstruction and atelectasis, but leads no closer to a solution of the problem in spontaneous "massive collapse" of the lung, where no evidence of foreign-body obstruction has been found.

Aspiration of secretions alone could hardly explain the condition since patients, aspirating barium sulphate through broncho-oesophageal fistulæ, never develop atelectasis. Likewise, no case is reported after tonsillectomy and there is abundant proof of the extreme degree of aspiration which frequently occurs during this operation. In no recorded autopsy was there any evidence of bronchial obstruction.

That it is possible for thick fluids to result in atelectasis under certain conditions is demonstrated in a case cited by Hickey, in discussing a recent

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communication by Dr. Preston B. Forestier. In Hickey's patient, massive collapse followed the intratracheal injection of iodized oil used for diagnostic purposes.

The rapidity with which the condition develops in certain instances, and the engorgement and dilatation of the capillaries suggests the possibility of vasomotor disturbance as a contributing etiological factor. Gwyn mentions that massive collapse may be due to some such action and Scott also is impressed with this possibility. Bergamini and Shepard state that the "uniform dilatation and engorgement of the capillaries, arterioles and venules strongly suggest a probable vasomotor disturbance." The rapid onset in the cases observed by them "would seem in itself to rule out the theory of obstruction of the bronchi with subsequent absorption of the alveolar air." They suggest some such explanation as angioneurotic oedema.

Posture alone as an etiological factor has been stressed by Scott and Joelsson. To cite one notable case in which massive collapse occurred in the contralateral lung on two successive occasions after operation on the two kidneys. Briscoe had previously suggested position as a possible cause.

The theory of combined obstruction and impaired respiration is the view upheld by Churchill.^{28, 29} He asserts that there can be no atelectasis without bronchial obstruction.

When we consider the facts, we have no clinical or experimental evidence for thinking that atelectasis can occur under any other condition than actual mechanical bronchial occlusion. If we assume that there can be no atelectasis without previous bronchial obstruction then the manner in which the obstruction is brought about alone remains to be considered. What extraneous influences are there which could account for the accumulation of secretion in the larger bronchi? Obviously, the loss of sensation of the trachea and larger bronchi and the consequent interference with the expulsive mechanism which is normally present—cough reflex and ciliary action of the mucous membrane. The cause of such loss of sensation on the part of the trachea and bronchi, then, becomes the chief point of consideration; atelectasis is merely the natural course of events which would be expected under these circumstances. Will loss of bronchial sensation explain all instances and circumstances under which the condition is found?

Infectious cases might well be explained in this manner. There is abundant evidence that extreme toxicity can abolish the tracheal reflex. This is seen in instances where individuals toxic from intestinal obstruction or septicaemia, aspirate barium sulphate into the lungs without discomfort. Pasteur's original cases following diphtheria, cases reported following acute poliomyelitis and Case I of our own series in which the causative factor was probably septicaemia, are examples. The loss of tracheal reflex in operative cases might also be explained either by anaesthesia produced by morphine, or other hypnotics given to quiet the patient, especially if he were permitted to remain in one position for an extended period of time after the operation. Pre-operative

administration of morphine has been offered as a possible explanation of post-operative abscess of the lung, the analgesia produced preventing the normal expulsion of infected material aspirated during operation. This theory would explain contra-lateral involvement which is occasionally encountered in post-operative atelectasis as seen in Case III of our series. The case referred to by Doctor Hickey in which massive collapse followed intratracheal injection of iodized oil, might well have been due to the previous injection of cocaine, administration of morphine, or large doses of luminal (which is supposed to counteract the constitutional effect of cocaine) prior to injection and permitting the patient to lie quietly after injection. But toxicity *alone* will not explain all cases in which the phenomenon occurs.

There remain for consideration those cases in which the condition develops after injury (Cases IV and VI of our series), and severe physical strain. It is conceivable that some reflex might result from injury to a remote part of the body. It is not uncommon to see patients so severely injured in one part of the body that the pain from a less severe injury elsewhere is inhibited or overshadowed. During the war it is possible that severe fighting conditions, high nervous tension and extreme exhaustion incidental to battle, might result in the inhibition of the cough reflex. Numerous instances have been encountered during the war and in civil life where abdominal operations were performed without an anæsthetic upon individuals in a profound state of exhaustion. In the strain of competitive athletics could not the great nervous tension and muscular effort (Case II) produce such reflex inhibition from fatigue?

The one constant finding in all instances is immobilization (not paralysis) of the diaphragm. While the collapse itself is often on the opposite side to the operation or injury which precedes the condition, the diaphragmatic immobilization is always on the same side as the collapsed lung. If aspiration of secretions alone were the cause, diaphragmatic excursion should be resumed after the dislodgement of the obstruction and reinflation of the lung. This is not found to be the case; diaphragmatic immobilization often remains for days or weeks after reinflation. This would seem to indicate that it is inactivated in a defense reflex.

Is it not conceivable that the bronchioles might also be contracted from a similar reflex spasm? Sibillant râles have been detected by others intermittently over the lung during the time preceding collapse, and the same observation has been made by clinicians in our cases before it was known that collapse was developing. May it not be possible, then, that collapse occurs as a result of a combination of all of the factors here noted?

It seems most logical to suppose from the available evidence that massive atelectatic collapse of the lung results from a simultaneous inhibition of the cough reflex by some toxic or reflex stimulus in association with an impairment of the respiratory function, either immobilization of the respiratory muscle from a defense reaction, or paralysis from toxic neuritis. This in turn permits the accumulation of secretions, blocking the bronchi and resulting in

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atelectasis. Posture favors the development in the most dependent portion. Occurring alone, these factors may not be sufficient to produce the condition; their simultaneous occurrence, however, may be all that is necessary to result in collapse.

DIFFERENTIAL RÖNTGENOLOGICAL DIAGNOSIS

Massive (atelectatic) collapse of the lung must be differentiated from: (1) Lobar pneumonia. (2) Lung abscess. (3) Caseous tuberculous pneumonia. (4) Broncho-pneumonia. (5) Lung tumor. (6) Pleural effusion. (7) Chronic interstitial pneumonia.

If one bears in mind the clinical history and the typical Röntgen picture of massive (atelectatic) collapse, none of these conditions should cause confusion.

Massive (atelectatic) collapse most frequently follows abdominal operations or other injury to the chest, abdomen, or pelvis. The onset is sudden with pain in the chest, fever, dyspnoea, rapid pulse and leucocytosis. There are the physical signs of massive consolidation. At this stage the condition may resemble lobar pneumonia, especially insofar as pneumonia is a frequent post-operative complication. The one distinctive sign is the retraction of the heart and mediastinal structures toward the involved side and sinking in of the chest wall on that side. Uncomplicated lobar pneumonia does not produce deviation of the trachea or displacement of the mediastinal structures. If alveolar absorption takes place rapidly and there is still some obstruction of the bronchi by secretions, displacement of the trachea may be present as a manifestation of the atelectasis present. Under these circumstances lobar pneumonia in the resolving stage cannot be differentiated from massive collapse. If only a single lobe, for instance the upper, is collapsed, the phenomenon of sinking in of the chest and pulling over of the heart does not occur, since the slight difference in space caused by collapse of a single lobe is compensated for by emphysema of the remaining aerated lung. Even in this instance, however, there will be definite displacement of the trachea which will establish the true nature of the condition. If there is ever doubt about the consolidation being due to lobar pneumonia, lung abscess, caseous tuberculous pneumonia, or any consolidation other than massive collapse, a safe diagnostic procedure is to roll the patient over upon his uninvolved side and cause him to cough. An atelectatic lung where there is no bronchial obstruction should immediately reinflate; consolidation from other cause will not be affected.

After a few days the patient begins to cough, and after a time brings up a varying amount of mucopurulent sputum. At this stage the condition may be mistaken, clinically, for lung abscess or caseous tuberculous pneumonia. Röntgenographically, however, the picture is usually quite distinctive. The formation of secretion, it should be remembered, is one of Nature's methods by which inflation is reestablished, so that at this stage, patches of reinflation may be seen here and there in the atelectatic area, and the picture may become confused. With beginning reinflation of the lung, the first structure to return to normal position is the trachea, so that this might have resumed its position in midline if there is much evidence of reinflation. The narrowing of the

interspaces and shallowness of the chest on the affected side would still be present to establish the diagnosis, however. At a somewhat later stage, where the process has been allowed to go on to reinflation by degrees, a stage is reached in which all of the displaced structures again assume their normal positions, and even at this stage there may be considerable irregular atelectatic areas remaining in the lung. It may, just at this time, be impossible to differentiate the condition from broncho-pneumonia. Massive collapse, however, is unilateral, and broncho-pneumonia is usually bilateral.

Tumors of the lung may reach such enormous proportions as to completely fill the chest. Such tumors may continue to grow until they cause a displacement of the heart and mediastinal structures to the opposite side, but they never cause retraction toward the involved side, unless by their growth they occlude a bronchus which results in subsequent atelectasis.

Large pleural effusions, likewise, may produce a homogeneous shadow involving one entire side of the chest. In this condition, displacement of the heart and mediastinal structures away from the involved side is the rule. Such displacement may not be present due to fixation of the mediastinum from previous infection, but retraction of the mediastinal structures toward the involved side never results. Occasionally a long-standing pleural effusion may have developed sufficient scar tissue in its surrounding capsule to cause retraction of the trachea, but this is very rare, and the other elements of the case will usually establish the true nature of the process.

Chronic interstitial pneumonia (chronic diffuse fibrosis of the lung) is the only other massive consolidation which causes retraction of the heart and mediastinal structures *toward* the involved side. This condition is chronic, however, usually following some suppurative process in the chest and the scar tissue which causes the pulling over of the mediastinum likewise exerts its traction on the walls of the bronchi, causing bronchiectatic cavities to form. These can be clearly seen through the consolidation. They never occur in association with massive atelectatic collapse.

TREATMENT

The fluoroscopic observation of immediate reinflation of the collapsed lung after rolling the patient back and forth on the uninvolved side (affected side uppermost) and causing him to cough, gives a logical basis for this procedure as a therapeutic measure. This simple expedient has resulted in immediate reinflation in every instance which we have observed, and numerous confirmations of the observation have been brought to the writer's attention in this country and abroad. Chevalier Jackson and his co-workers, Hearn and Clerf, have shown that reinflation occurs following bronchoscopic removal of mucus from the bronchi. The process of reinflation may be slow, however, and often is complete only after several bronchoscopic examinations. It would seem advisable, then, in all instances to attempt the simple expedient of rolling the patient on the uninvolved side and causing him to cough before bronchoscopic procedure is instituted. Should this measure fail to produce reëxpan-

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sion, bronchoscopic examination should be resorted to, in order to detect any mechanical cause for the collapse. Doctor Jackson and members of his clinic have demonstrated numerous instances of atelectasis from bronchial occlusion by new growths, foreign bodies and anomalies of the bronchi; these conditions represent atelectasis from mechanical obstruction and are in no way similar to the cases here under discussion. Obviously simple change in position would have no effect on the atelectasis produced under such circumstances and bronchoscopic examination would be indicated for the detection of its cause.

SUMMARY

1. Massive atelectatic collapse of the lung is a definite clinical entity. This name should be reserved for cases following out the general clinical course herein mentioned, in which there is collapse of a previously well-aerated lung without mechanical obstruction from foreign body, tumor or anomaly. This name is not entirely descriptive of the condition and will probably give place in time to a more scientific designation. The term "acute lobar idiopathic atelectasis" has been suggested by Dr. Seth I. Hirsch.* Congenital atelectasis and atelectasis from mechanical cause such as foreign bodies, tumors and anomalies should not be so considered.

2. It is characterized by sudden collapse of one or more lobes in a lung previously well aerated, from some unknown cause.

3. It is most frequently observed after abdominal operations, wounds and other injuries such as fractures of the pelvis or femur, but may follow apparently trivial injuries.

4. Röntgenographically, there is a dense consolidation corresponding to one or more lobes or to an entire lung, homogeneous in character and resembling consolidation from pneumonia. The narrowing of the chest on the involved side, the approximation of the intercostal spaces, the elevation of the diaphragm and the drawing over of the heart and mediastinal structures toward the involved side, make the condition readily recognizable.

5. It seems most logical to suppose that the condition is due to a simultaneous inhibition of the cough reflex by some toxic or reflex stimulus in association with an impairment of the respiratory muscles, either immobilization from a defense reaction or paralysis from toxic neuritis, which permits secretions to accumulate and block the bronchus, and atelectasis results. Neither alone is able to bring about this condition; a simultaneous occurrence is necessary for its development.

6. The treatment is simple and consists in rolling the patient back and forth on the uninvolved side. Ordinarily no other therapeutic agent is necessary. This simple procedure has, in all instances in which we have instituted it (five), proved successful in promptly reestablishing aeration of the lung. Jackson and his co-workers have reported reinflation after repeated

* Personal communication.

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bronchoscopic removal of mucus from the bronchi and bronchoscopy should be resorted to if this simple manœuvre fails.

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SURGICAL LESIONS OF THE BILIARY TRACT *

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THE clinical and statistical features of this report are based on a study of two hundred consecutive cases of diseases of the biliary tract, admitted to the service of the writer during the past four years in the wards and private rooms of The Brooklyn Hospital.

The majority of these patients (about 65 per cent.) had been previously observed and a provisional diagnosis made in our out-patient department, but after admission to the hospital, all of them were personally studied and cared for by the writer, or one of his associates, with the definite aim of attempting to clarify our own opinions and the viewpoint of our staff as well as to correlate, if possible, certain clinical and operative findings with the laboratory studies and end results. After hospitalization most of these patients were again returned to the clinic for follow-up observation and appropriate after-care where they were seen at regular intervals by the same members of the hospital staff; thus ensuring a unified system of surgical care and sequential study in the hands of a rather small group of men.

The results of laboratory investigations included, are based not only on a study of the two hundred cases covered in this analysis, but also on the examination of material secured from the patients of other surgeons in the same hospital. This review of pathological material was undertaken by James Denton at the same time that our clinical observations were begun. In all, over four hundred gall-bladders were studied and the results of Denton's observations were summarized and published in the *Archives of Surgery*, in January, 1927. In brief, he was able to characterize lesions of the biliary tract as primarily mechanical and circulatory disturbances rather than infectious ones. This conception, while at complete variance with the generally accepted explanation of gall-bladder disease, has been found of value to us in establishing a better understanding of the conditions encountered and we, therefore, propose to present an analysis of our material in the light of this altered point of view.

In the first place, it may be of advantage to delineate briefly our conception of the salient features of biliary tract disease, based primarily on clinical observations but attempting at the same time to keep in mind the results of pathological and bacterial studies which we believe to be accurate and useful.

In our experience, by far the greater number of disturbances of the biliary tract which may be successfully managed by the surgeon, and with the greatest relief and satisfaction to the patient, are those which have their basis in obstruction to the normal flow of bile through the duct system and by far the most common and frequent cause of such obstruction is the presence of stones,

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gravel, or inspissated bile in the gall-bladder, cystic, common or hepatic ducts. The symptoms and effects of stones depend on their size, number, to some degree on their chemical characteristics, and finally on their location in the duct system. They may be found in any of the following places:

1. In the intrahepatic ducts.
2. In the extrahepatic ducts.
3. In the gastro-intestinal canal.
4. In the peritoneal cavity.
5. In the gall-bladder.

Stones in the Intrahepatic Ducts.—When stones are located in the intrahepatic ducts the damage done to the liver depends on whether the stones are large or small, single or multiple, and upon what proportion of the duct system is involved or obstructed. If, as is usual in this location, the stones are small or in the nature of what is commonly called gravel, only partial obstruction of the duct radicles ensues, the effects are not serious and usually confined to a small portion of the liver. When of greater size and located in the larger intrahepatic radicles the entire liver will be intensely engorged with bile and there may result extensive necrosis of liver cells from back pressure. This condition is probably what is generally termed or understood as hepatitis in association with biliary tract disease. Intrahepatic stones may be complicated by an ascending cholangitis but in this location they do not often lead to complete occlusion of the duct system, and the condition is seen more often at autopsy than clinically.

Stones in the Extrahepatic Ducts.—Stones in the extrahepatic ducts constitute the most serious result of gall-stone formation. In this location, the gravity of the situation depends, in a large measure, upon the completeness of the occlusion. Cases are not infrequently seen at autopsy in which a stone of considerable size had been present in the common duct for a long period of time with enormous dilatation of the duct and still with no serious effect on the liver substance. Sudden and complete obstruction of the duct by stone, however, always results in obstructive jaundice and invariably calls for prompt surgical intervention. In contradistinction to the gall-bladder, impaction of stone in the common duct is not infrequently complicated by ascending infection of the duct system and ascending cholangitis results. This, of course, adds to the seriousness of a condition already in itself a menace to life. Cholangitis is, as a rule, obviously infective or bacterial in origin.

If a stone is impacted in the ampulla of Vater and if the ampulla receives both the bile and pancreatic ducts, either the retrojection of bile into the pancreas or escape of pancreatic enzymes may result in hemorrhagic necrosis of the pancreas. That hemorrhagic pancreatitis is frequently a complication or result of obstruction or inflammatory disturbances in the biliary system, there can be little doubt.

Stones in the Gastro-intestinal Canal.—Four cases of partial or complete intestinal obstruction due to the presence of large gall-stones in the intestinal canal, have been observed in The Brooklyn Hospital during the past few years. The location of the fistulæ through which they have entered the intestine has been variable, but in each instance it was assumed that stones of such enormous size (in one instance as large as a hen's egg) must have ulcerated

through the gall-bladder wall into an adherent loop of intestine; the size of these stones was such as to have precluded their original presence or existence in any location other than the gall-bladder.

Gall-stones in the Peritoneal Cavity.—We have operated on three patients in whom gall-stones were found free within the cavity of the peritoneum. In two of these the rupture of the organ was apparently spontaneous; there was little or no evidence of gall-bladder pathology and the peritonitis ensuing was nothing more than a transitory chemical reaction from the irritation of the biliary secretion on the peritoneum. The third case was that of a ruptured gangrenous gall-bladder in which a simple drainage operation resulted in the uncomplicated recovery of the patient. In this case, numerous stones were lost within the peritoneal cavity, but after a lapse of three years the patient has never manifested any symptoms referable to the presence of these foreign bodies. Other cases have been reported in which gall-stones were found encysted within the folds of the omentum or in other locations within the peritoneal cavity. They may, and in some instances do, lead to localized abscess formation, but rupture of the gall-bladder and the escape of bile and stones into the general peritoneal cavity need not necessarily cause more disturbance than a transitory chemical peritonitis.

Stones in the Gall-bladder.—The presence of stones in the gall-bladder may or may not be accompanied by symptoms or appreciable pathological changes in the organ or any other part of the biliary tract. Such stones appear often to be harmless foreign bodies although invariably a potential source of trouble and danger. We have on many occasions, when operating for other conditions, seen gall-bladders both large and small containing many stones in which the patient had never complained of symptoms and in which the organ grossly and histologically showed little or no pathological change. Cultures made from gall-bladders freshly removed and containing stones were frequently returned with negative results, and stained sections of many parts of the mucosa and gall-bladder wall in numerous instances failed to reveal the presence of bacteria, and showed none of the characteristic changes associated with infection.

In cases, on the other hand, in which pathological change is easily recognizable, such changes appear to be the result of mechanical and circulatory disturbances due to the presence of a foreign body and usually to its impaction in the cystic duct.

That a secondary infection may and often does develop as a result of the presence of stones, and the trauma produced thereby cannot be denied and yet, we are entirely at variance with those who maintain that gall-stones do not develop except in the presence of an infected medium and that they are invariably the end-result of bacterial invasion.

It seems to us as the result of our own clinical and laboratory experience, that a disturbance or unbalance of body chemistry in its relation particularly to cholesterol and calcium metabolism must be the important and primary factor in the etiology of cholelithiasis. It would seem also that the recent

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investigations of Wells, Benda, Dewey, Boyd, Sweet and others would tend to support this contention.

Gradual occlusion of the cystic duct by a stone appears usually to result in mucous hydrops of the gall-bladder. Sudden occlusion is accompanied by marked edema of the gall-bladder wall and hemorrhage either into the cavity of the organ or between its several layers. This is the condition observed after a severe biliary colic associated with impaction of a stone in the cystic duct and if repeated often enough there ensues marked thickening and fibrosis of the gall-bladder wall itself.

Such effects are produced in the first instance by interference with the venous circulation, and when severe enough to seriously obstruct or block the arterial supply, there results a partial or complete infarction or gangrene of the organ, depending upon the degree of occlusion or thrombosis of the vessels.

There can be no question but that stones pass down through the duct system and into the intestine. In cases where the gall-bladder shows obvious pathological change but where no stones are found it is not unreasonable to assume that such changes had their origin in circumstances connected with the previous presence and passage of calculi.

We cannot agree with those who have likened the acute gall-bladder to the acutely infected appendix. Their constitutional symptoms, temperature reaction, blood picture, pathogenesis and bacteriology are not in any way analogous.

The acute gall-bladder, even though perforated and with a resultant intra-peritoneal abscess, rarely shows any tendency toward the development of a spreading peritonitis and the organisms recovered from such cases are of different strains and types from those associated with suppurative lesions of the appendix. In so-called empyema of the gall-bladder, in which the cavity of the organ is distended with a thick mucoid material of yellowish or greenish-yellow tinge, we have often failed to recover pathogenic organisms and smears were frequently negative for pus cells and bacteria. Even in the most severe cases in which secondary infection had supervened, the formation of plastic exudate and other evidences of a spreading and severely infective peritonitis, such as are often seen in the lower abdomen, were lacking.

In chronic disease of the gall-bladder in which no stones were found the pathologic changes most commonly noted were fibrosis and involution atrophy, the same as may be seen in many other tissues and organs in patients past middle life. It is our belief that such changes may be understood and explained on the basis of circulatory disturbance associated with prolonged or chronic venous stasis of mechanical origin.

In the pathological material examined in such cases in our series the presence of infection could not be demonstrated.

CLINICAL ANALYSIS

When we began these observations, about four years ago, it was decided to institute a logical method of study and procedure and except for a few acute

cases, obviously in need of prompt surgical relief as an emergency measure, the policy of conservatism was adopted for two reasons:

First: Because we had come to believe that the average acute gall-bladder may, with advantage, be allowed to subside and the surgical procedure undertaken after the cessation of acute symptoms with greater safety to the patient.

Second: For the reason that in many patients with suspected biliary tract disease we have felt that sufficient time should elapse, not only for the purpose of making complete and accurate diagnostic studies, but also in the interest of determining, in each instance, the factor of safety or operative risk.

Since the adoption of this policy we are aware of no instance in which it has been detrimental to the patient, whereas previously, when it was our custom to regard the average acute gall-bladder as similar to suppurative appendicitis, and to institute radical surgical measures with corresponding promptitude, we can recall several instances in which disastrous results might have been avoided by a more careful and delayed consideration of the surgical indications and predetermination of the operative risk.

The method of observation and study which we have applied to these patients has been in no way different from those measures employed in many other surgical clinics. Without unnecessary waste of time we have attempted to utilize, in logical order, all of those various diagnostic and pre-operative aides which have come to be recognized as of any direct or indirect value and by so doing it has been possible in most instances to make accurate estimations of the underlying pathology, to convert poor operative risks into comparatively safe ones, and to carry out the indicated surgical procedure at a time and in a manner least detrimental to the patient.

Without going into the details of history, physical signs, X-ray findings and laboratory data, the analysis of our cases may be best summarized in tabular form.

TABLE I.

Analysis of 200 Cases of Biliary Tract Disease.

Acute cases (with primary or recent colic).....	23
Acute exacerbations in chronic cases (based on pathology).....	31
Chronic cases (including 8 carcinomas).....	146
Total.....	200

Age limits—15 to 86 years.

Males—50. Females—150. Ratio—1 to 3.

Distribution in Decades.

2nd Decade.....	2 cases
3rd Decade.....	29 cases
4th Decade.....	46 cases
5th Decade.....	57 cases
6th Decade.....	47 cases
7th Decade.....	16 cases
8th Decade.....	2 cases
9th Decade.....	1 case
Total.....	200 cases

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TABLE II.
Cholelithiasis.

Acute cases.....	42
Chronic cases.....	78
	<hr/>
	120 or 60%
<i>Associated Pathology.</i>	
Pancreatitis—In acute cases.....	16
Pancreatitis—In chronic cases.....	22
	<hr/>
	38 or 19%

TABLE III.
Gastric and Duodenal Ulcer Associated.

Ulcer—Gastric.....	Acute cases— 2
Ulcer—Gastric.....	Chronic cases— 4
Ulcer—Duodenal.....	Acute cases— 2
Ulcer—Duodenal.....	Chronic cases—21
<i>Malignant Disease.</i>	
Carcinoma gall-bladder and common duct.....	4
Carcinoma hepatic duct.....	1
Carcinoma pancreas.....	3
	<hr/>
	8 or 4%

TABLE IV.
Appendectomy and Cholecystectomy.

Acute cases.....	16
Chronic cases.....	79
	<hr/>
Total.....	95
Pathologic appendices (gross pathology) about 10 per cent.	

TABLE V.
X-Ray Studies.

Gastro-intestinal series (including gall-bladder) taken in.....	108 cases
Of diagnostic value in.....	94 cases
Stones shown by X-ray in.....	24 cases
Extra-biliary evidence of gall-bladder disease in.....	70 cases
<i>Tetraiodide Test (Graham).</i>	
Made in.....	90 cases
Agreement with operative findings in last 11 cases. (Value apparently increasing with cumulative experience.)	

TABLE VI.
Surgical Résumé.

Patients operated upon.....	184
Patients not operated upon.....	16
<i>Cases not Operated Upon.</i>	
Acute—Allowed to subside.....	5
Acute—Moribund on admission.....	1
	<hr/>
	6
Chronic—Refused operation.....	1
Chronic—Pregnancy.....	1
Chronic—Risk out of proportion to symptoms.....	8
	<hr/>
	10
Total.....	16

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TABLE VII.

Operations.

Cholecystectomy.....	165
Cholecystostomy.....	11
Choledochostomy.....	10
Cholecystgastrostomy (cancer of pancreas).....	2
Simple drainage of gall-bladder and localized abscess.....	2

Associated Operations.

Appendectomy.....	95
Gastro-jejunostomy.....	3

TABLE VIII.

Mortality.

Operations—184	Deaths—18	Rate	9.7%
Cancer cases—5 (gall-bladder, hepatic and pancreatic ducts).....			2.7%
Deaths in acute cases (6 in 54).....			11. plus
Deaths in chronic cases (7 in 146).....			4.7%
Combined mortality (exclusive of cancer).....			7. %

TABLE IX.

Analysis of Operative Deaths.

(Exclusive of Cancer Cases.)

Acute Cases.

No.	Age	Sex	Pathology	Operation	Course and cause of death
1	40	F	Acutely inflamed gall-bladder stones, hemorrhagic pancreatitis	Drainage of gall-bladder and pancreas	Never rallied. Died two days post-op. with profuse biliary and pancreatic discharge.
2	48	F	Perforated gall-bladder, stones, localized intraperitoneal abscess	Cholecystostomy and drainage	Almost moribund on admission. Died 22 hours post-op.
3	25	F	Acutely inflamed and distended gall-bladder, stone in cystic duct	Cholecystectomy appendectomy drainage	Went into shock on table, improved with stimulation, never rallied, died 36 hours post-op.
4	25	M	Spontaneous perforation of common bile duct, pancreatitis, biliary peritonitis	Choledochostomy, drainage. No stone found	Gradually failed with pancreatic asthenia, died 22 days post-op.
5	45	F	Stone in common duct, spontaneous perforation and rupture of common bile duct biliary peritonitis	Choledochostomy and drainage	Died 48 hours post-op. of peritonitis and toxic ileus.
6	50	F	Perforated gall-bladder intra-abdominal abscess	Cholecystostomy drainage of abscess	Died 48 hours post-op. with general peritonitis.

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TABLE X.

Analysis of Operative Deaths.

(Exclusive of Cancer Cases.)

Chronic Cases.

No.	Age	Sex	Pathology	Operation	Course and cause of death
1	40	F	Distended thick gall-bladder buried in liver, few small stones	Cholecystectomy and appendectomy	Died of surgical shock two days post-op.
2	51	F	Large flabby gall-bladder, dense adhesions, hard pancreas	Cholecystectomy and appendectomy	Died two days post-op. of renal insufficiency and anuria (no. P. S. P. done.)
3	30	F	Thickened gall-bladder. No stones, adhesions	Cholecystectomy	Ligature on cystic vessels slipped, much hemorrhage, op. shock, pneumonia, died on 5th day.
4	50	F	Thin walled gall-bladder, many stones	Cholecystectomy	Died 5th day post-op. with myocardial failure following auricular fibrillation.
5	61	M	Old thickened gall-bladder, atrophied, stone in common duct, long period of obstructive jaundice	Cholecystectomy, choledochostomy and drainage	Died 5th day post-op. asthenia, hypostatic pneumonia, myocarditis.
6	68	F	Thickened gall-bladder buried in adhesions, pyloric obstruction, ulcer duodenum	Cholecystectomy and gastrojejunostomy	No reparative power, wound never healed, asthenia, died 22 days post-op.
7	31	F	Moderately thickened gall-bladder, no stones, anomalous vessels	Cholecystectomy	Anomalous vessel radicles, hemorrhage profuse, shock, died in 24 hours.

TABLE XI.

End Results of Follow-up Study.

Patients discharged after operation as recovered or improved.....	166
Patients followed at regular intervals during 4 year period.....	71
<i>Good result</i> —No symptoms, no hernia, entirely well. 48 cases associated with stone formation.....	56
<i>Fair result</i> —Partially relieved but with vague digestive disturbances, discomfort, painful and tender scars, etc.	8
(Equally divided between stone cases and those without stones)	
<i>Poor result</i> —Complaining of same symptoms as before operation and incisional hernia in 4 cases.....	6
(2 cases with stone, 4 without)	
<i>Died</i> —Cancer of pancreas—cholecystgastrostomy.....	1
(Died 1 year after operation)	

Eight cases readmitted to hospital for secondary operation on common duct, appendix, ulcer of duodenum, or stomach, repair of hernia, etc.

COMMENTS AND CONCLUSIONS

In this analysis several factors are worthy of special comment:

It is noteworthy that at operation stone formation was present in 120, or about 65 per cent., of the total number of cases operated. In 108 X-ray studies, the presence of stone was demonstrable in only twenty-four patients, or about 22 per cent. of those in which such examinations were made.

Malignant disease was found in eight patients and constituted 4 per cent. of the total.

Obstruction of the common bile duct with jaundice was observed in ten cases or 5 per cent. of the entire series. There was no instance of accidental injury to the duct system.

While in this series cholecystectomy was the operation of election for gall-bladder disease, cholecystostomy, or simple drainage operations, were done in eleven of the acute cases as an emergency measure. We feel that this simpler procedure should be more frequently utilized in the acute, bad risk patient, reserving the radical and complete operation for a subsequent time.

In the analysis of our end-results it may be seen that the patients who obtained the most permanent and complete relief from symptoms were those with cholelithiasis; that they sought relief because of repeated attacks of biliary colic or because of an acute episode characterized chiefly by severe right upper quadrant pain, not relieved by ordinary measures. At operation, in these cases, it was found that they were almost invariably associated with impaction of stone in the cystic or more rarely the common duct and that the underlying pathology was not primarily infectious in origin but due chiefly to mechanical and circulatory disturbances with resultant œdema, hemorrhage, hydrops or infarction. When actual infection was shown to be present it seemed to us to be a complication, or late result, rather than the primary lesion.

The cases, on the other hand, which were least satisfactory in permanent relief of symptoms were those not associated with cholelithiasis: who sought relief, not because of severe pain or colic, but who presented that vague train of digestive disturbances which have been so often ascribed to chronic infection of the gall-bladder. In cases not exhibiting more definite pathological changes than slight fibrosis or involution atrophy and presenting this well known vague group of symptoms, we have come to believe that such gall-bladders should be less frequently sacrificed than has been the recent practice of many surgical clinics, and that the causes for such symptoms should be sought for elsewhere and corrected by means less hazardous and with better end-results than have followed the too frequent removal of this organ.

The term "cholecystitis," either acute or chronic, implies the presence of infection. Does it always portray an accurate picture of the most frequently encountered and predominant surgical lesions of the gall-bladder?

CLOSURE OF THE ABDOMEN WITHOUT DRAINAGE AFTER OPERATIONS UPON THE BILE TRACTS

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IN THE twelve years since we began to advocate the primary closure of the abdomen after operations on the bile tracts, the trend of surgical practice has gradually swung toward that direction. Many surgeons, however, still cling to the practice of routinely draining these wounds. In a recent article, Wangsteen concludes, on the basis of a case of his own and from a number described in the literature, that the "so-called ideal cholecystectomy is not a safe procedure; that drainage after cholecystectomy is imperative; that it is a safeguard and does no harm." W. J. Mayo has closed tentatively, without drainage, in a series of cases, but states that "a little drain is a comfort to the surgeon and sometimes a life buoy to the patient." In the European literature, too, there has been a reaction away from the routine use of the drain, but the majority of surgeons still follow the old practice of leaving drains or tampons in all cholecystectomy wounds. Moynihan writes, "There are surgeons who like to close the abdomen after removal of the gall-bladder, and there are surgeons who do not. I place myself with confidence among the latter. I never close the abdomen without a drain, though in the days of my adventurous youth I often did." Hartmann objects to extensive tampons and limits himself to small drains, but is afraid to relinquish them entirely. The veteran Körte writes, "He who is wise will stick to the drain," and Enderlen declared to the German Surgical Society, "I have been reared in the fear of God and the Peritoneum," and thinks primary closure is permissible only in carefully selected cases. This middle view, that the abdomen may and should be closed in the presence of certain well-defined and rigidly observed indications, is maintained by Haberer, Payr and others. Obviously, the conception as to what constitutes indications varies widely in the different clinics.

In our own work, we have been closing the abdomen without drainage in gall-bladder operations for over twelve years. We have increasingly widened our range of indications, and are strongly convinced of the safety and of the advantages gained in omitting the drain. We close our incisions after common duct work, and after trans-duodenal choledochotomy, as well as after simple cholecystectomy. We usually follow this practice in acutely infected cases as well as in chronic, relatively aseptic ones, and do not regard the spilling of bile or of duodenal contents in the field of operation a contra-indication. If there is uncontrollable oozing from the liver bed, a gauze pack is left in place; if in common duct operations, the accurate suture of the duct is

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impossible, or if some other special contra-indication exists, we place a drain in the incision. Otherwise, we do not drain. We have closed primarily in 262 bile tract operations, and with one possible exception which will be described later, have yet to regret having omitted the drain. This report is based on 400 consecutive gall tract cases, special consideration being given to the question of drainage. Table I.

TABLE I.

Group	Operations	Drained			Not drained			Total		
		Cases	Mortality		Cases	Mortality		Cases	Mortality	
			No.	%		No.	%		No.	%
I	Simple cholecystectomy...	29	1	3.45	204	2	0.98	233	3	1.29
II	Cholecystectomy plus common duct work.	38	3	7.89	27	2	7.41	65	5	7.69
III	Cholecystectomy plus other major work...	3	0	0.00	22	2	9.09	25	2	8.00
IV	Simple cholecystostomy...	54	3	5.55				54	3	5.55
V	Cholecystostomy plus common duct work	7	2	28.57				7	2	28.57
VI	Cholecystostomy plus other major work...	11	0	0.00				11	0	0.00
VII	Primary common duct work	10	5	50.00	2	0	0.00	12	5	41.66
VIII	Miscellaneous	4	2	50.00	7	1	14.27	11	3	27.27
	Totals	156	16	10.26	262	7	2.67	418	23	5.50

In Table I, are listed the 418 operations performed on 400 consecutive patients, with diagnosis of gall tract disease. For purposes of clarity, they are divided into eight groups on the basis of the type of operations done. It will be seen that cholecystectomy was done in 323 cases, sixty-five times with additional common duct work, and twenty-five times associated with some other major abdominal surgery. The appendix is usually removed as a matter of routine and is not included as additional "major" work. Of the 323 cholecystectomies, the wound was drained in seventy and closed primarily without drainage in 253 cases. Simple cholecystectomy with primary closure of the incision was done 204 times with two deaths, an average mortality of 0.98 per cent. One of these deaths was due to acute pancreatitis, the other to a pulmonary embolus on the day on which the patient was to have left the hospital. The average mortality in all of the cholecystectomized cases, including those with common duct or other major operative work was 3.39 per cent. It will be noticed that the percentage of fatalities is higher in the drained groups than in the not drained. The obvious explanation, of course, is that the severest and most difficult cases are the ones which most frequently required drainage. This explanation accounts, too, for the relatively high

DRAINAGE AFTER OPERATIONS UPON THE BILE TRACTS

mortality in the cholecystostomized cases. Thus, the gall-bladder has been drained seventy-two times with a total mortality of 6.94 per cent. In the group of simple cholecystostomy without other associated work, there were three deaths in fifty-four cases. These represent, for the most part, the poorest risk cases; jaundiced subjects, overwhelming infections, debilitated patients. Twelve cases are listed as primary common duct operations. They represent for the most part, plastic procedures on the common duct; although a few cases of choledochotomy for stone where the gall-bladder had been previously removed, are included. As is to be expected, the mortality in this group was the highest. The common duct was operated upon in all eighty-four times in the series. Twelve of the twenty-three fatalities occurred in these common duct cases. In the last group eleven cases are listed as "miscellaneous." They comprise cholecyst-gastrostomy or cholecyst-duodenostomy because of carcinomatous obstruction of the common duct, four cases; one case in which adhesions were broken up; one exploration in a case of congenital absence of the gall-bladder, one in an inoperable carcinoma of the gall-bladder; one in an acute suppurative hepatitis; one in an obscure jaundice of hepatic origin; one case of simple drainage of a biliary peritonitis; and one of abscess associated with recurrent carcinoma of the gall-bladder. There were twenty-three deaths in the entire series, giving a total operation mortality of 5.50 per cent., a patient mortality of 5.75 per cent. Table II.

TABLE II.
Fatalities.

Group	Case No.	Age	Pathology	Operations	Drain	Complications and course	Time
I	207	29	Cholelithiasis	Cholecystectomy	No	Uneventful convalescence. Sudden death on day of discharge. Pulmonary embolism	9 da.
	294	49	Cholelithiasis	Cholecystectomy	Yes	Acute nephritis. Uremia. (Autopsy)	7 da.
	390	43	Cholelithiasis, chronic pancreatitis	Cholecystectomy	No	Repeated attacks of acute pancreatitis with severe collapse, ileus and death. Eventration	16 da.
II	32	64	Cholelithiasis, common duct stone	Cholecystectomy choledochotomy	Yes	Nephritis	6 da.
	88		Acute Cholecystitis with stones. Common duct stone. Acute cholangitis	Cholecystectomy choledochotomy	No	Clinically, death of pulmonary origin. Autopsy not obtained	2 da.

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TABLE II. *Continued.*

Group	Case No.	Age	Pathology	Operations	Drain	Complications and course	Time
II	261		Cholelithiasis, common duct stones	Cholecystectomy choledochotomy	Yes	General peritonitis. Incision reopened, source not found. Fluid contained no bile. Suprapubic drainage	3 da.
	286	41	Stricture of common duct from stones. Jaundice "White Bile"	Cholecystostomy choledochotomy 1 month later. Cholecystectomy choledochostomy Duct dilated	Yes	Hepatic insufficiency. Hemorrhage. Chronic pancreatitis. Shock.	2 da.
	229	61	Cholecystostomy 3 weeks ago for acute G. B. Stricture of common duct from inflam. or stone	Cholecystectomy choledochotomy Duodenotomy. (Ampulla incised)	No	Peritonitis. (Autopsy)	6 da.
III	93	57	Previous cholecystostomy. Cholelithiasis. Uterine fibroid	Cholecystectomy. Myomectomy and suspension, (sep. incision)	No	Clinically a pulmonary death but no autopsy	2 da.
	214	47	Acute cholecystitis. Gastric ulcer. Pyloric obstruction	Cholecystectomy Gastro-enterostomy	No	Obstruction at G-E opening. Re-laparotomy and entero-anastomosis. No peritonitis	2 da.
IV	121		Acute cholecystitis	Cholecystostomy	Yes	Rupture of heart, sudden death. (Autopsy)	1 da.
	205	73	Acute gangrenous cholecystitis. Jaundice	Cholecystostomy	Yes	Jaundice. Senility	2 da.
	324	33	Cholelithiasis. Common duct stones. Icterus gravis	Cholecystostomy	Yes	Jaundice. Hemorrhage. Anuria. Term. pneumonia	15 da.
V	83	30	Cholelithiasis. Common duct stone	Cholecystostomy. Choledochotomy. Duodenotomy	Yes		7 da.
	289	27	Cholelithiasis. Common duct stone. Jaundice	Cholecystostomy. Choledochotomy	Yes	Jaundice. Hemorrhage. Jaundice persisted. Wound reopened, tubes filled with blood clot. Death from cholemia and hemorrhage. (Autopsy)	9 da.

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TABLE II. *Continued*

Group	Case No.	Age	Pathology	Operations	Drain	Complications and course	Time
VI	106	23	Stricture of common duct following cholecystectomy elsewhere	Choledochostomy 4 months later. Plastic on common duct	Yes	Jaundice. Cholemia. Hemorrhage. (Autopsy)	1 da.
	274	56	Cholelithiasis. Common duct stones. Jaundice	Choledochostomy	Yes	Cholemia. Oozing. Death from hemorrhage.	1 da.
VII	245	34	Biliary peritonitis. Stricture of common duct following cholecystectomy elsewhere. Jaundice	Simple drainage several months later. Plastic on ducts	Yes	Jaundice. Uncontrollable oozing. Repeated blood transfusion. Death from hemorrhage.	8 da.
	308	25	Operative damage to common duct. Jaundice	Choledochostomy 3½ mo. later. Plastic repair of ducts	Yes	Jaundice. Asthenia. Hemorrhage. Abdomen re-opened on day of death for bleeding	4 da.
	320	41	Cholelithiasis. Common duct stones. Jaundice. "White Bile." Pancreatitis	Choledochostomy	Yes	Jaundice. Hepatic insufficiency. Pancreatitis. Hemorrhage	1 da.
VIII	188	54	Previous cholecystostomy. Cholecystitis. Cirrhosis of liver. Jaundice of obscure hepatic origin	Exploration (findings same)	Yes	Jaundice. Cirrhosis. Gradual wasting with persisting jaundice. Death following simple exploration	1 da.
	157	63	Carcinoma of hepatic flexure of colon. Cholelithiasis	Cholecyst-gastrostomy. Ileo-colostomy	No	Suppurative parotitis. Septic infarcts in lung. Multiple gastric ulcers. (Autopsy)	42 da.
	307	57	Previous cholecystostomy. Carcinoma of gall-bladder. Recurrence with infection	Simple drainage	Yes	Immediate post-operative course favorable. Thrombophlebitis with death two days later.	7 da.

In Table II are listed all of the fatalities occurring in the series, with a statement giving as accurately as possible, the cause of death in each case. From the two foregoing tables, several salient observations are to be noted. The importance of early operation, that is, while the pathologic changes are still limited to the gall-bladder, is clearly indicated. Thus, the mortality rate in the simple cholecystectomized patients was 1.29 per cent. as against a mortality of 14.28 per cent. in all of the cases requiring work on the common duct. And of the three deaths occurring in the simple cholecystectomy group, the one from pancreatitis (Case 390) can scarcely be included among the early cases. The safety of closing the abdomen without drainage is also brought out. Sixteen of the twenty-three deaths were in drained cases (10.27 per cent. mortality), while only seven (2.68 per cent. mortality) occurred in the non-drained ones. This difference, as mentioned before, is largely due to the fact that the most difficult, and poorest risk cases are the ones most often requiring drainage. Nevertheless, it emphasizes the relative safety of primary closure. Among the non-drained fatalities, there was only one death from peritonitis (Case 229). This is the single instance referred to above in which it might have been better to drain. The patient, a woman of sixty-one, came under observation during an attack of acute cholecystitis. A simple cholecystostomy was done, and she reacted well, although there was an unusual degree of shock for the limited amount of work done. Three weeks later, the gall-bladder was removed, the common duct incised, and sounds passed in both directions. Obstruction to the sound was encountered in the region of the ampulla, and the duodenum was opened. The ampulla was incised, permitting the sounds to be passed through what appeared to be a stricture from previous inflammation or stone. Peritonitis developed, terminating fatally on the sixth day. The diagnosis of peritonitis was confirmed at autopsy. While it is doubtful whether the presence of a drain would have altered the outcome in this case, since it did not prevent those deaths from peritonitis in the drained cases, the wisdom of the primary closure may be questioned. In Case 88, in which the gall-bladder was removed; the common duct incised, freed of stones sutured; and the abdomen closed without drainage, all in the presence of acute infection plus jaundice, the error in judgment was probably in doing too much rather than in omitting the drain. With these possible exceptions, there has never been occasion to regret having closed without drainage in gall tract operations, and the procedure, in our hands, has proved to be safe and satisfactory.

It is to be emphasized that in the group of over two hundred simple cholecystectomies closed without drainage, only one death, that from pancreatitis was of abdominal origin, and it is difficult to associate this fatality with the question of wound drainage. In the entire series of 262 cases of all types which were closed without drainage, there was only one in which death was definitely due to peritonitis.

The advantages gained for the patient by omitting the drain after gall tract operations are for the most part obvious, and have been too often

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described to require discussion. In comparing the post-operative course in drained and non-drained cases, Coventry found that the former had much more pain, particularly pain radiating to the shoulder; more post-operative tympany, nausea and vomiting; more elevations of the pulse and temperature. The stay in bed after primary closure is shortened, as is also the stay in the hospital and the entire period of convalescence. The patient is spared the pain, the shock, and frequently the anæsthetic required in removing the drains. The escape of bile from the incision, so often observed in drained cases, and so often mentioned as an argument against the primary closure does not occur when there is no drain. The presence of a foreign body in the wound leading directly to the outside, certainly predisposes to infection from without and interferes with the body's mechanism for the combating of such infections. The development of incisional hernia is favored by this almost inevitable infection. Willis, Buchbinder, and others have demonstrated that the formation of post-operative adhesions, with their attendant discomforts and disabilities is promoted by the pressure of the drain; and von Haberer calls attention to the greater likelihood of thrombosis and embolism and the possibility of secondary hemorrhage because of the drain.

Since we have gradually widened our range of indications for closing without drainage, an analysis of 100 consecutive recent cases was made, to see in what proportion of current cases drainage is omitted. The results are listed in Table III.

TABLE III.
Analysis of 100 Consecutive Recent Cases.

Group	Operation	Drainage	Cases	Average post-op. stay in bed	Average p. o. stay in hospital	Deaths
I	Simple cholecystectomy	No drain	66	7.01 days	13.45 days	1 (No. 390)
		Drained	4	10.25 days	21.75 days	
II	Cholecystectomy plus common duct	No drain	9	15.66 days	24.33 days	
		Drained	6	7.67 days	18.17 days	
III	Cholecystectomy plus other major work	No drain	6	8.00 days	16.17 days	
		Drained	0			
IV	Cholecystostomy		4	23.67 days	38.67 days	1 (No. 324)
VII	Primary common duct work	No drain	1	12.00 days	16.00 days	2 (Nos. 308 & 320)
		Drained	2			
VIII	Miscellaneous	No drain	1	3.00 days	13.00 days	1 (No. 307)
		Drained	1			

From this table it is seen that the gall-bladder was removed in ninety-one of the 100 cases, seventy times without other work, fifteen times together with operative work on the common duct, and in six associated with some other major surgical procedure. Of the seventy simple cholecystectomies, four

were drained. One of these was an acute case with considerable cholangitis, and the cystic duct stump was not ligated; in two the drain was inserted because of persistent oozing from the liver bed, and in the fourth, there was an acute gangrenous gall-bladder which ruptured during the removal causing considerable soiling with highly infectious material. It will be noted that post-operative stay in bed and the stay in the hospital were considerably shorter in the non-drained cases. The average stay in bed in this group was seven days. This is interesting in light of von Haberer's repeated warning that when these incisions are drained, the drain must be left in for a minimum of twelve days. According to this, the majority of our non-drained cases are discharged from the hospital before the others may be relieved of their drains. In those cholecystectomized cases in which the common duct was also opened, nine were closed without drainage and six were drained. Curiously, the convalescence here was more rapid in the drained cases, the explanation being that recovery in several of the non-drained group was delayed by complications of one type or another, in no case abdominal, and in so small a series of cases, the *average* length of the post-operative course is materially increased. Of the entire 100 cases, eighty-three were closed tightly, without drainage, and seventeen including the cholecystostomized ones were drained.

The chief argument advanced against primary closure is that of danger from bile leakage. That such leakage occurs when the wound is drained, is common knowledge, and the assumption is that if the incision had not been drained, a serious or, perhaps, fatal biliary peritonitis would have ensued. There is evidence, however, to indicate that such bile leakage occurs much less often in non-drained cases than in drained ones, and which would seem to suggest that the drain itself is a factor in causing the escape of bile. Blalock, reviewing all the gall-bladder cases operated upon at Johns Hopkins Hospital over a period of thirty-five years, reports that 38 per cent. of the cholecystectomies (the incision in all cases had been drained) drained bile after the operation. Holman, observed bile drainage twenty-two times in sixty-eight cases and Walzel and Wiesentreus found ten in ninety-nine simple, drained cholecystectomies in von Eiselsberg's Clinic. Vigyázo places the incidence of such bile flow at approximately 10 per cent. Bile leakage in non-drained cholecystectomy, on the other hand, is a rare occurrence. Isolated cases have been reported here and there, and in many of these gross error in technic probably played a rôle. In our own work, we have never had to reopen the abdomen because of insufficiency of the cystic duct stump. We have had occasion to evacuate biliary accumulations from the peritoneal cavity in two cases, both of which had been operated upon elsewhere. In one case, there had been gross injury to the hepatic duct with consequent escape of bile. In the other, the gall-bladder had been removed and the abdomen closed without drainage. There were stones in the common duct, however, which had been overlooked, and which may have caused obstruction of the duct. We were not able to discover whether there were any other gross technical errors which might have accounted for the choleperitoneum. Accidents such

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as these can scarcely be laid to the omission of the drain, and it raises the question whether some of the reported incidents of bile accumulation may not have been due to some similar cause.

That the drain itself may be the source of bile leakage in uncomplicated cases is claimed by Stettin and others, and has also been experimentally demonstrated. Vigyázo and Schulhof removed the gall-bladder in a series of animals, leaving the cystic duct stump wide open. The animals remained well and at re-laparotomy there was no evidence of peritonitis or bile accumulation. The end of the cystic duct was firmly closed off by adhesions from the omentum and surrounding viscera. In other animals, the top of the gall-bladder was cut off and in others the gall-bladder was split longitudinally and sewed inside-out. In these experiments, too, the abdomen was closed without drainage, the animals remained in good health, and re-operation revealed walling-off the gall-bladder region without evidence of bile accumulation. In subsequent experiments, the liver was extensively injured, and the abdomen closed without drainage in some instances, with drains or tampons in others. Those closed primarily all remained well. Those tamponed or drained, became icteric, and re-operation showed that healing was interfered with by the presence of the drain.

It has also been claimed that bile leakage may be due to aberrant ducts running directly from the liver to the gall-bladder, or to dilated subcapsular ducts which are torn in the removal of the gall-bladder (Haberland, Wazel). Holman described three cases with anomalous branches of the biliary ducts, which he felt provided further justification for drainage after cholecystectomy. Moynihan states that the presence of accessory ducts, so fine that they escape notice, requires drainage in 15 per cent. of the cases. We have personally seen a spurt of bile from a dilated biliary duct in the liver bed, which had to be ligated. These occurrences must be rare, however, as is evidenced by the fact that bile leakage does not occur after primary closure. And should such an anastomic variation be present it is reasonable to assume that, in the absence of a drain, the leakage is prevented by adherence of omentum and bowel, such as occurred in the experiments of Vigyázo. This last named author states that leakage due to such anomalies is rare. He summarizes by saying that the source of the post-cholecystectomy bile flow is only rarely due to insufficiency of the cystic duct stump. The frequent "benign" cholerrhagia, he attributes to lesions of the liver bed as a result of the shelling out of the gall-bladder, or to tears of the liver parenchyma from too rough handling. He considers the tampon an important factor in maintaining the flow, by interfering with the biologic agents concerned in the healing of such lesions, and by interfering with the adhesion of the omentum over the defect.

Granting that, in an occasional case, because of some unusual anatomic anomaly, or a gross technical error, bile may escape from the ducts and accumulate in the peritoneal cavity, it has often been shown that such a choleperitoneum is relatively innocuous. That the highly infective contents of gangrenous gall-bladder, which goes on to spontaneous perforation may lead

to a serious peritonitis, is of course obvious. The contents of the ordinary, chronically infected or calculus containing gall-bladder, however, have often been found sterile. And when organisms are present, they are usually of low virulence. It has even been found (Ehrhardt) that bile in the peritoneal cavity protects against bacterial peritonitis, and it is probable that the bile in the gall-bladder depresses the virulence of the contained organisms. Wangsteen presents a representative review of literature regarding the danger of bile in the peritoneal cavity. He cites numerous cases of traumatic rupture of the bile tracts with large intraperitoneal accumulations, which were well borne for many days or weeks, and which often yielded to simple puncture or incision. He states further that "a number of experimental investigators have concerned themselves with this problem, and with one exception have all concluded that sterile bile may be present in the peritoneal cavity without harm." In his own experiments, after ligating the common duct and cutting a hole in the fundus of the gall-bladder, the animals died very quickly. As he points out, however, there are several essential differences between such conditions and those prevailing in the human subject at operation. He attributes death to the toxic action of the absorbed bile, stating that the bile in the dog contains much more taurocholic acid, while human bile contains relatively more of the less toxic glycocholic acid. The diversion of all the bile from the intestinal tract is undoubtedly also a factor, accounting for the delayed death in untreated cases of choleperitoneum.

We have had occasion to observe two cases of intraperitoneal bile accumulation within the past few years, both of which were due to gross operative accident, and both of which suffered relatively little harm from the presence of the bile. In both cases, drainage gave complete relief.

CASE 275.—Mrs. O. W., age fifty. The patient gave a history of gall-bladder attacks extending over a period of one year, with slight jaundice accompanying one severe attack. She was operated upon elsewhere, December 2, 1924, cholecystectomy was done and the abdomen closed without drainage. After operation, she continued having abdominal pain and vomiting, became much worse a week later, and jaundice appeared. The stools were colorless, the urine very dark. These symptoms persisted until about January 1, 1925, when an accumulation of fluid developed beneath the incision. This was evacuated, symptoms subsided and jaundice disappeared. On January 6, the drainage stopped, pain in the abdomen reappeared, and persistent vomiting of greenish fluid again developed. The patient was then brought to our service at Wesley Hospital. On admittance, her temperature was 99, pulse 90, and there was a moderate degree of jaundice. The entire abdomen was greatly distended and tender, and there was flatness and a fluid wave in the right upper quadrant. Peristalsis was diminished over the entire abdomen, and there was a leucocytosis of 14,000. Diagnosis of "Injured common duct with localized accumulation under tension in right hypochondrium and a general biliary peritonitis," was made and operation performed. The old incision was reopened, and a walled-off accumulation of bile in the epigastrium was evacuated. There was also a large accumulation of bile-colored fluid in the free peritoneal cavity, estimated at about 3 litres, and considerable in the pelvis. The peritoneal surfaces were slightly reddened and there were occasional fibrinous deposits. The fluid was aspirated, the wound closed with drainage, and counter drains placed in a second suprapubic incision. The patient felt much better immediately after regaining consciousness, and convalescence was without incident.

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Radical operation was done two and one-half weeks later. There were dense adhesions everywhere, and a bile-stained peritoneal exudate. The common duct was exposed, found to be enormously dilated, to a diameter of an inch or more. The common duct was incised, a large quantity of bile and several small stones escaped. Several more stones were removed, and male urethral sounds were passed in both directions. The source of the bile leakage was not discovered. A large accumulation of bile-colored fluid, estimated at about a quart, was evacuated from the right kidney fossa and a smaller accumulation in the infra-hepatic region was also drained. The abdomen was closed with drainage. Her recovery was entirely uneventful, except for the development of an incisional hernia, which has since been repaired.

CASE 245.—Mrs. T. L., age thirty-four, was operated upon elsewhere on February 16, 1924, for gall-stones; gall-bladder and appendix were removed, and the abdomen was closed without drainage. She continued to have pain and slight irregular elevations of temperature after the operation. The stools were acholic, and there was gradually increasing distention of the abdomen. When seen ten days after operation, the patient was in good general condition, temperature was 100, pulse 100. The abdomen was distended, peristalsis diminished, stools acholic and there was a moderate degree of jaundice. On February 28, the abdomen was reopened. A large quantity of bile was found in the peritoneal cavity, and a small incision was seen in the right hepatic duct. The fluid was evacuated, drains inserted, and the abdomen closed. The patient was discharged from the hospital, March 13, in good condition, and with only slight drainage from the incision.

The drainage persisted for about three months, then the sinus closed. About one week later jaundice reappeared. Patient was readmitted to the hospital, definitely icteric. After preliminary preparation with intravenous calcium chloride injections, the abdomen was reopened on July 12. Stricture of the hepatic duct was found, close to its entrance into the liver. The stricture was dilated gradually until No. 18 male sounds were passed. A small rubber tube was introduced into the hepatic duct toward the liver, and its end brought through the abdominal incision. Cigarette drains were placed and the incision closed. There was free bleeding throughout the operation, with a gradual fall in blood pressure which necessitated blood transfusion. The oozing persisted despite repeated transfusions, condition became gradually worse, and the patient died eight days after the operation.

These two cases are cited as instances of intra-peritoneal bile accumulations, both of which were due to gross technical operative error, and in both of which, the presence of a relatively large amount of bile in the abdomen was well tolerated. In the one case a massive accumulation had apparently been present for a month or longer without seriously impairing the patient's condition or producing severe manifestations. At operation, evidences of very mild peritoneal reaction were present, and the condition cleared up promptly following simple evacuation and drainage. In the second case, the patient was up and about despite an increasing accumulation of bile in the peritoneal cavity. Here, too, simple evacuation and drainage brought prompt recovery. The patient's ultimate death following operation for stricture of the hepatic duct was, of course, in no way associated with the previous choleperitoneum.

There is one other fallacy in the treatment of cholecystectomy wounds to which we have once before called attention. Many operators are willing to close the abdomen without drainage if the cystic duct stump can be adequately buried, and innumerable procedures have been devised and advocated for concealing the end of the duct somewhere behind the peritoneum. This we consider to be wrong in principle. The capacity of the peritoneum for pro-

tecting against infectious and irritant substances has often been demonstrated, and the peritoneum is usually able to take care of whatever leakage may possibly take place from a cystic duct stump. The escape of such substances into retroperitoneal spaces, however, where the tissues have infinitely less resistance would be much more serious. In the technic employed by us, the cystic duct is carefully isolated, clamped, divided, and tied with a single catgut ligature. A separate ligature is usually placed on the cystic artery. No attempt is made to bury the stump of the duct behind the peritoneum nor to cover the raw surface in the liver bed. Whatever exudation takes place, be it bile or blood, can flow unhindered into the peritoneal cavity, where it is disposed of with least harm to the organism.

SUMMARY

1. Report is based upon 400 cases operated upon because of bile tract disease, special consideration being given to the question of abdominal wound drainage.

2. In 262 of the cases, the abdomen was closed without drainage, including twenty-nine cases in which the common duct was opened and sutured, and twenty-two cases requiring other major surgical work in addition to that on the bile tracts.

3. Of the seven deaths occurring in these 262 cases, only one could definitely be ascribed to peritonitis.

4. There have been no gross accidents resulting from the primary closure, and with the one possible exception we have yet to regret having closed an abdomen without drainage.

5. There were two fatalities in 204 simple cholecystectomies closed without drainage, only one of which was of abdominal origin. Death in this case was due to pancreatitis and was unassociated with the question of wound drainage.

6. The frequent bile drainage occurring after operations in which the incision is drained, is not seen if the drain is omitted.

7. Omitting the drain, minimizes the post-operative discomforts; reduces the incidence of infection-hernia; and shortens the post-operative stay in bed, stay in hospital, and period of convalescence.

8. On the basis of the above reported material, we are convinced of the safety and desirability of closing the abdomen without drainage after operations on the biliary tracts, and urge its wider application.

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HIDDEN PERFORATION OF THE GALL-BLADDER

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THIS condition was called to my attention at the post-mortem of a woman fifty years of age, whose chief complaint was vomiting, present for two years, and becoming progressively worse. There was neither pain nor discomfort. She had lost eighty pounds in weight in one year. On physical examination the stomach was found to be enlarged and to contain fluid. No masses were noted in the abdomen and there were no areas of tenderness elicited. A provisional diagnosis was made of pyloric obstruction from carcinoma of the stomach. At operation a hard, firm, nodular mass about eight centimetres in diameter was found at the pylorus which could not be delivered so a posterior gastro-enterostomy was done. The mass was thought to be carcinomatous. The patient died a few days later and at the post-mortem examination the mass was found to involve the pylorus, the first portion of the duodenum, the gall-bladder, and the adjacent part of the liver; it could not be separated due to the thick adhesions. On sectioning the mass was seen to be not a malignant tumor but an ulceration of the gall-bladder with perforation due to multiple stones. Two stones were found obstructing the pylorus and the first part of the duodenum, one between the duodenum and gall-bladder and a fourth stone in the gall-bladder, all being tightly bound down by dense adhesions.

Perforation of the gall-bladder is a comparatively rare condition. In this clinic from October, 1920, to October, 1927, there were 1270 gall-bladder cases operated, of which sixteen, or 1.2 per cent. were perforated. McWilliams (cited by Blaudstein¹) reviewed a total of 3180 operations on the biliary tract and encountered perforation in twenty-nine, or 0.9 per cent. Blaudstein also reports Karullon's figures from an analysis of 6114 autopsies in which 572 cases had gall-stones, three, or 1.5 per cent., of which had perforated.

The condition occurs more frequently in women than in men, probably due to the fact that gall-bladder disease affects the female more often than the male. Of the sixteen cases of perforation in this clinic, twelve were women and four were men. The majority of these cases were over fifty years of age; the oldest being seventy-four and the youngest twenty-seven.

We have found only three cases in which perforation followed the first attack of abdominal pain. The duration of these symptoms varied from twenty hours to six days. The other cases had had many attacks and the length of time from the first attack to the time of perforation was from five months to nine years. Most of the cases developed their first symptoms between the ages of forty and fifty years.

The most common symptom is pain in the right hypochondriac region,

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which may or may not radiate to the scapula and right shoulder. The next most common symptom is epigastric pain, occasionally accompanied by vomiting. Jaundice is rarely present. Indigestion was the chief complaint in one patient and vomiting in one. At operation stones were encountered in eleven; adhesions in five; pus in six; bile in the abdominal cavity in three; gangrenous



FIG. 1.—Openings in gall-bladder and duodenum due to rupture of gall-bladder into duodenum. Shows position of stones.

gall-bladder in one case; pyloric obstruction in one; fistula between the gall-bladder and colon in one; and rupture of the gall-bladder into the abdominal wall in one case.

A correct pre-operative diagnosis was made in one case. In the others the diagnosis was: gall-bladder disease four; acute appendicitis two; abdominal tumor one; pyloric obstruction one; chronic calculous cholecystitis with empyema one; perforation of intestines with peritonitis one; five not diagnosed.

The operative diagnoses were as follows:

Chronic calculous cholecystitis with perforation seven; acute calculous

cholecystitis with perforation two; perforation with gangrene one; empyema of the gall-bladder with rupture two; acute suppurative cholecystitis with perforation one; acute ulcerative calculous cholecystitis one; rupture of the gall-bladder into the abdominal wall one; carcinoma of the pylorus one. In

this last case (the one referred to at the beginning of this discussion) the correct diagnosis was made at autopsy.

Cholecystectomy was done in ten cases with two deaths; cholecystostomy with drainage of the surrounding region in two with one death; choledochostomy one, this is included in one of the fatal cases of cholecystostomy; incision and drainage was done in two cases with one death; posterior gas-



FIG. 2.—Stones from ruptured gall-bladder.

tro-enterostomy in one case followed by death. Postmortem examination was made in this and in one other case.

Perforation may occur into any one of several regions depending upon the etiology and rapidity of the process. Acute perforation usually takes place into the free peritoneal cavity, for here nature has not had sufficient time to wall off the gall-bladder with adhesions. The process is usually due to ulcerative cholecystitis, the colon bacillus, typhoid bacillus, and streptococcus being the most common organisms found. Stones are not so often found as in the more chronic cases. Trauma is also a factor, but is exceedingly rare due to the protection of the gall-bladder anatomically. Alexander² reports one case due to trauma in 1000 cases of gall-bladder disease and this was due to a gunshot wound. There is usually present a distended and diseased gall-bladder.

Subacute and chronic perforation may take place into the small intestine, pylorus, stomach, colon, occasionally into the liver substance and very occasionally a stone may work its way through to the surface of the body.

When the stones penetrate the alimentary canal they usually cause intestinal obstruction. Surgical intervention is necessary as a rule but at times the stone passes spontaneously. Courvoisier's³ statistics (cited by Deaver and Ashhurst) show that the site of impaction is in the duodenum and jejunum in 21.4 per cent., ileum 65 per cent., ileocaecal valve in 10 per cent. and the sigmoid flexure in 2.4 per cent. I have found four cases including our own in which the obstruction was at the pylorus.⁴

The mortality of perforated gall-bladder is very high. Theoretically this should not be so where perforation occurs into the abdominal cavity in

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view of the excellent protection given the gall-bladder by the surrounding anatomical structures; the parietal peritoneum, the under surface of the liver, the transverse colon, and the omentum all tending to prevent the foreign material from spreading and thus limiting the resulting peritonitis. Practically, however, this is not borne out, for the patient usually has had several gall-stone attacks and believing this to be a similar attack refuses operation. Thus perforation of the gall-bladder becomes one of the most fatal forms of perforation. The records of the Lankenau Clinic show a mortality of 43 per cent. Gossett, Desplas and Bonnett⁵ in analyzing 111 collected cases of perforation of the gall-bladder into the abdominal cavity, find a mortality of 52.2 per cent. Bennett,⁶ in 3064 cases of intestinal obstruction reports twenty-eight cases of intestinal obstruction due to gall-stones with a mortality of 50 per cent.

Diagnosis is very difficult and is seldom made until the abdomen has been opened, due to the rarity of the condition and the lack of pathognomonic signs. The acute perforation into the free peritoneal cavity is most frequently mistaken for perforated gastric ulcer or sometimes for a high lying appendix. The true condition is recognized when the bile-tinged peritoneum or peritoneal exudate is seen. In the subacute and chronic perforation there is often an antecedent history of gall-bladder symptoms and the presence of a more or less hard, movable mass that will lead one to suspect the condition. In pyloric obstruction, as in our case, it is often mistaken for carcinoma of the stomach for the symptoms simulate this condition very closely. In obstruction in other parts of the intestinal tract the only aid is a previous history of gall-bladder disease. This latter condition is very rare. Bennett⁷ collected only twenty-eight cases in 3064 cases of obstruction (0.9 per cent.).

CONCLUSIONS

1. Perforation of the gall-bladder is comparatively rare, occurring in about one per cent. of diseased gall-bladders.
2. There are no pathognomonic symptoms but a careful history in which previous gall-bladder attacks have been present should lead one to suspect the existing condition. The exact diagnosis is rarely possible before operation but the nature of the condition should lead one to explore the upper abdomen.
3. The treatment is early surgical intervention, the procedure depending upon the age, condition of the patient and condition of the gall-bladder, but cholecystostomy with drainage of surrounding area seems the method of choice.
4. The mortality is about 50 per cent. and can be decreased only by early diagnosis and early treatment.

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LATE INTESTINAL STENOSIS FOLLOWING STRANGULATED HERNIA

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LATE intestinal stenosis following strangulated hernia has received little consideration in the American surgical literature. The observation of this condition five times in the last three years has therefore prompted us to briefly review the subject and to report these cases.

In short, the history of one of these cases is as follows:

A patient is operated upon for strangulated hernia. The intestine is found badly compromised but apparently viable and is replaced. At first everything goes well. There are no signs of peritonitis or intestinal obstruction. After a varying, free interval, ranging from weeks to months, the patient develops severe, colicky abdominal pain. The picture of an incomplete, mechanical ileus then supervenes, which demands further operative intervention. Laparotomy, at this time, reveals as the cause of obstruction either (1), an area of tubular stenosis due to fibrosis of part or all of the strangulated loop, or (2), an annular stricture corresponding to the zone of intestinal constriction at the neck of the sac.

Pathology.—In the *early* stages of strangulation, the changes in the wall of the affected loop are venous stasis, œdema and a certain degree of hemorrhagic extravasation. Relief of the constriction at this time will result in a complete return to normal.

The *advanced* stages of strangulation are characterized by two features: firstly, a progressive devitalization of portions of the affected gut; and secondly, the development of permanent interference with circulation, due to thrombosis of the vessels in the intestinal wall or in the smaller mesenteric radicles. These are the cases that will undergo perforation even after the constriction is relieved.

There is an *intermediate* stage, however, in which though complete devitalization does not occur, the pathological changes at the time of operation are so advanced, that relief of the strangulation will no longer permit of a return to normal. In such cases, late intestinal stenosis may result.

To understand the pathogenesis of this last named condition the histological changes in a strangulated loop must be more closely considered. A study of these indicates that the different layers of the intestinal wall exhibit different degree of sensitivity to interference with their blood supply. Numerous post-mortems and the examination of resected specimens have

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shown that if the condition has progressed sufficiently for necrosis to occur, areas of the mucosa are the first to be involved, with the formation of ulcers. The muscular layers are next involved. The connective tissue elements, both submucosal and subserosal maintain their viability longest. When the stage of mucosal gangrene is reached, thrombosis in some of the smaller radicles of the affected loop are already present. These are important as they result in a permanently diminished blood supply to the affected part. This diminished vascularity interferes with the regenerative potentialities of the mucosa, which are normally very great. In fact, Schloffer,¹ years ago, demonstrated that experimental excision of even extensive areas of mucosa was followed by regeneration, and that intestinal stenosis or stricture could

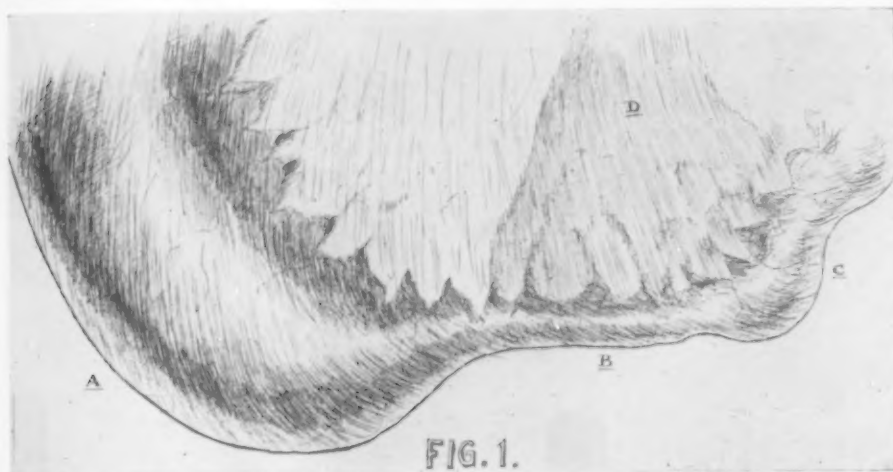


FIG. 1.—Semi-diagrammatic sketch of the specimen in Case IV. (Drawn by Dr. J. B. Stenbuck.)
A. The greatly dilated proximal loop. B. The area of stenosis. C. Distal collapsed intestine.
D. Thickened mesentery of the affected segment.

be experimentally produced only by interference with the blood supply of a given segment.

The other important factor in the final development of a fibrotic stenosis is infection. The bowel denuded of its protecting mucosal coat, and its resistance lowered by the diminished circulation, is invaded by intra-intestinal organisms. An inflammatory granulation tissue is formed which at first produces hypertrophic obstruction of the intestinal lumen and later undergoes fibrotic changes causing a scar tissue stricture. It must be remembered that in the small intestine there may be pathological narrowing without any clinical manifestations. Haasler³ has reported a few cases in which fibrotic small intestinal stenosis was an incidental finding in patients dying of other causes. It had apparently given rise to no symptoms during life.

The changes at the intestinal grooves ("Schnürfurche"), due to the direct constriction by the edges of the hernial ring, deserve a word for themselves. Hoffmann² in a study of fifty-six resected specimens, showed that the histological changes at these points were similar to, but occurred

earlier and were more marked than those present throughout the rest of the affected loop. At these zones, the *mucosa* is again the first to undergo necrosis, the *serosa* apparently not being involved until late, in spite of the direct pressure upon it.

When the changes as outlined above affect the entire loop of strangulated gut, a remarkable picture is finally produced. (Fig. 1.) The greatly dilated bowel, proximal to the obstruction, terminates abruptly in a narrow thick-walled, firm, rigid tube from two to five inches in length, and one-half to one-quarter the diameter of the normal bowel. The mesentery of the involved portion is thickened fibrotic and contains numerous enlarged glands, so that the condition may be mistaken for a local tuberculous process or

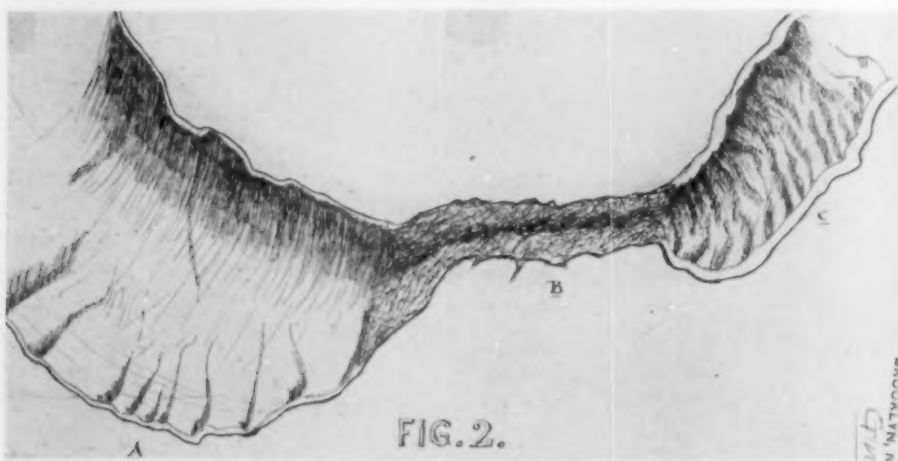


FIG. 2.—See legend under Figure 1.

even malignancy. Distally, this area is again sharply demarcated from normal small intestine. There is a tendency for the involved segment to become adherent to the intestine immediately proximal and distal to it, producing an "S"-shaped coiling. When opened, the lumen of the stenotic portion is found greatly narrowed, at times barely admitting a medium-sized probe. It is lined by granulation tissue with scattered patches of hypertrophic mucosa. In the earlier stages mucosal ulceration in various stages of healing may be present (Case V).

When the changes have occurred only at the *constriction grooves*, an annular hypertrophic stricture denuded of mucosa is found. It is most apt to occur at the proximal constriction zone, but at times both are involved with the formation of a double stricture.*

Microscopically, in both the tubular and annular forms the mucosa is absent except for isolated hypertrophic patches, and the submucosa is replaced by a hypertrophic inflammatory granulation tissue. The muscu-

* Since the completion of this article, two cases of annular stricture have been reported by Eising, in the American Journal of Surgery.

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laris mucosæ is disrupted. There is marked inflammatory, subserosal thickening and varying degrees of fibrosis in the muscular layers.

Symptoms.—In the majority of cases there is a free interval after operation of at least two or three weeks. The most frequent time for the development of symptoms is in the third or fourth week. Many cases, however, are symptom free for a considerably longer period, extending over months and in some of the reported cases, even years. Premonitory symptoms of diarrhœa or intestinal bleeding due to secondary sloughing of compromised areas may occur. Typically, however, the first complaint is of paroxysmal attacks of severe, generalized, colicky abdominal pain. This apparently bears a definite relation to the ingestion of food and in many instances is so constant that the patients voluntarily starve themselves. As the obstruction is in the small intestine, and in the beginning incomplete, there is passage of stool and flatus, a fact which is apt to obscure the sinister significance of the complaint. If the patient is seen during an attack of pain, visible peristalsis and borborygmus may be detected.

The symptoms usually become progressively worse with the development of the classical picture of an incomplete small intestinal obstruction. If the obstruction is not relieved, the patients go rapidly down hill, partly from starvation, partly from chronic toxic absorption, probably due to bacterial and chemical decomposition in the obstructed loops. This is especially exemplified in Case IV, reported below, where a severe anemia, resembling pernicious anemia, developed very rapidly. At autopsy in this case, hepatic changes similar to those occurring in a severe toxemia were found. Incidentally, the development of severe anemia resem-



FIG. 3.—Microscopic section of involved intestine in Case IV. 1. The normal mucosal structure is gone. At points the intestine is devoid of epithelial lining. 2. The muscularis mucosæ is disrupted and the submucosa shows an inflammatory infiltration.

bling the pernicious type, has been reported in cases of small intestinal stricture by Meulengracht and others.

The occurrence of attacks of severe abdominal colic, occurring in a patient in whom at the primary operation the intestine was found badly compromised, should immediately bring to mind the possibility of this condition. One should not be misled by the passage of gas or stool, or the absence of visible peristalsis, which in stout people may be difficult to detect.

The X-ray is of great value in diagnosis. At times, very important information may be obtained from an ordinary plate without the ingestion of barium, especially if there has been vomiting, or food has been withheld. The dilated loops of gut may then be well visualized because of their gaseous distention. If this examination is not productive of much information, recourse may be had to a small quantity of a barium mixture. The danger of converting an incomplete obstruction into a complete one by the barium must be borne in mind. The X-ray will show the typical picture of a partial small intestinal obstruction.

Treatment.—Operative intervention should be undertaken early and should consist either of resection of the involved portion of the gut or of a short circuiting entero-anastomosis. If resection is performed a lateral anastomosis is preferable to an end to end, because of the great disparity in the diameter of the proximal and distal loops. In the presence of numerous adhesions, or when the patient is in poor condition, entero-anastomosis is the preferable mode of procedure. It was performed in three of the cases reported below, with excellent results.

In those cases where the obstruction has been due to an annular constriction, a plastic operation similar in principle to the Heineke-Mikulicz pyloroplasty, has been used by some. In the presence of ileus with the changes present in the gut just proximal to the obstruction, this would seem to be a risky procedure without any special advantage.

At the time of primary operation, there are no positive criteria by which to judge the possibility of the development of a late intestinal stenosis. The intestine, both in our own and the other reported cases was apparently considered viable as judged by the ordinary symptoms of return of color, vascular pulsation, and the reappearance of peristalsis. With an intact and glistening serosa, there may already be extensive mucosal necrosis.

REPORT OF CASES

CASE I.—Mrs. B. K., aged sixty, was admitted to the Mount Sinai Hospital in May, 1924, with an irreducible femoral hernia of twelve hours' duration, accompanied by cramp-like abdominal pain and vomiting. Examination disclosed a strangulated femoral hernia turning upward over the lower margin of Poupart's ligament.

Primary Operation.—Under local anæsthesia, the femoral hernia was exposed through an inguinal incision. The sac contained brownish fluid with a slightly disagreeable odor (not fecal), and the intestine was bluish-black in color. The constriction was relieved and hot saline solution applied. After fifteen minutes' observation, the bowel apparently recovered completely. Normal color and peristalsis returned. The arterial pulsations were

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normal, there was no evidence of venous thrombosis. The serosal layer of the involved segment retained its normal gloss. The involved intestine was therefore considered viable and replaced in the abdomen.

Two weeks after the operation, the patient began to complain of severe paroxysms of abdominal colic, occasionally accompanied by vomiting. Abdominal distention set in, and in spite of the fact that enemas were always partially effectual, the tympanites became more marked. It was concluded that an incomplete obstruction of the small intestine was present. *Secondary Operation:* The abdomen was opened through a left rectus incision under local anaesthesia. After a few adhesions had been divided, it was seen that about two inches of intestine had become converted into a narrow, firm, cord-like, rigid structure. Proximal to this area, the bowel was found greatly dilated, distally, it was collapsed. An entero-anastomosis between the collapsed and dilated gut to either side of the obstruction was performed. The patient made an uneventful recovery.

CASE II.—R. G., aged fifty, was admitted to the Mount Sinai Hospital in September, 1926, with a strangulated femoral hernia. The hernia had apparently been irreducible for twenty-four hours. She had come in from out of town and on admission, was in very poor condition. In addition to the local condition, the patient was found to be suffering from chronic nephritis with a systolic blood pressure of 230.

Primary Operation.—Immediate operation was performed and a strangulated partial enterocoele (Richter's hernia) was found. After relief of the constriction, the intestine apparently recovered its viability. While it was not considered entirely safe to replace the intestine, a resection was out of the question because of the poor general condition of the patient. A loop of chromic gut was passed through the mesentery of the involved intestine and brought out through the wound. A few days later, a local discharge was noted in the wound. This fistula closed spontaneously within a few weeks.

Following her discharge from the hospital, the patient had no symptoms whatsoever, for about a month. Then she began to experience attacks of severe abdominal pain and vomiting, which increased in frequency and intensity. In January, 1927, five months after the original operation, she was admitted to the Bronx Hospital. On admission, definite intestinal erection and visible peristalsis were noted.

Operation.—The abdomen was opened through a four inch right rectus muscle splitting incision. An area of cicatricial stenosis about $2\frac{1}{2}$ inches in length and $\frac{1}{3}$ the diameter of normal gut was encountered in the lower ileum. It was intimately adherent for its entire length to the tremendously dilated proximal loop. The gut distal to the stenotic area was of normal diameter. A suture anastomosis was performed between the gut proximal and distal to the obstruction. The patient made an uneventful recovery.

CASE III.—B. G., aged forty-five, was admitted to the Mount Sinai Hospital in January, 1925. About two and one-half months before admission, the patient had suddenly developed a strangulated inguinal hernia which was operated at another hospital. The findings at this operation are not at our disposal. Following his discharge, he commenced to have cramp-like circum-umbilical pain. The pain was more or less constant, with exacerbations coming on one or two hours after meals. He frequently induced vomiting for relief. Marked constipation had been present. Because of the definite relation of the pain to the intake of food, the patient was referred to the Mount Sinai Hospital, with a diagnosis of possible duodenal ulcer. On admission, the abdomen was distended, and marked borborygmus and visible peristalsis were found. A barium enema showed no abnormality of the colon. Because of the obstructive symptoms, an X-ray with oral ingestion of barium was considered inadvisable. A diagnosis of intestinal obstruction was made.

Operation.—The abdomen was opened through a four inch paramedian incision. A segment of collapsed gut, apparently distal ileum, was encountered and followed to the site of obstruction. A firm, hard, stenotic, greatly narrowed area of intestine $2\frac{1}{2}$ inches long was encountered. The mesentery of this portion of the bowel contained

numerous enlarged, but not especially hard glands. Proximal to the involved segment, the gut was greatly dilated, distally it was collapsed. An entero-anastomosis between the collapsed and dilated gut was performed, and a gland excised for microscopic examination. This was later reported to show chronic inflammatory changes. There was no evidence of tuberculosis or neoplasm.

A few days after operation, an enterostomy was performed for paralytic ileus, with marked relief of symptoms. Four months later the fistula, not having closed spontaneously, its operative closure was undertaken. At this time, the previous site of operation was reviewed in order to be certain that there was no obstruction distal to the fistula. The involved segment of gut was noted to be in the same condition as at the primary operation. The entero-anastomosis between the gut just proximal and just distal to the obstruction was patent. The fistula was accordingly excised and the opening in the intestine closed by suture. The patient made an uneventful recovery, and has remained well to date.

CASE IV.—M. L., aged forty-five, was admitted to the Mount Sinai Hospital in September, 1926. She had been operated on four years ago at another hospital for a left inguinal hernia, which had apparently recurred shortly afterwards. Eight hours before admission it had suddenly become large, painful and irreducible. She had vomited three times. Examination revealed an irreducible inguinal hernia about the size of a small grapefruit. An immediate operation was performed and a bilocular sac containing brownish slightly foul smelling fluid was found. Two loops of intestine were found to be incarcerated, one of which showed considerable cyanosis with subserous hemorrhage. After a prolonged period of observation and irrigation with warm saline, the loop was considered viable and was replaced. The subsequent course was uneventful and the patient was discharged well at the end of two weeks.

For four months following the operation the patient was apparently entirely free from symptoms. At that time she began to experience occasional attacks of colicky abdominal pain. There was no vomiting or constipation. At the same time a recurrence of the hernia was noted. The symptoms were apparently attributed to the recurrence and another hernioplasty was performed. Shortly afterward the patient was seen in the return clinic, and visible peristalsis noted. A gastro-intestinal X-ray was taken which showed unmistakable evidence of an incomplete small intestinal obstruction. Laparotomy was advised but refused. One month later the patient was readmitted to the hospital in a moribund condition with signs of intestinal obstruction and a marked anemia closely resembling pernicious anemia. The blood count follows: "Hæmoglobin 50 per cent.; red blood-cells 2,280,000. Hæmoglobin index 1.1. Numerous macrocytes; a few red blood-cells with stippling, two normoblasts. The picture is suggestive of pernicious anemia. Her condition was too poor to warrant operation." And the patient ceased soon after admission. *Autopsy* showed the following: 80 cm. above the ileo-cæcal junction the intestine shows a narrowing 8 cm. long. The area is about $\frac{1}{3}$ the diameter of the normal intestine. The ileum proximal is markedly dilated. In the region of the stricture the wall of the intestine is markedly thickened and the lumen markedly stenotic. The mucosa is cicatricial and there are polypoid excrescences of the preserved mucosa. Microscopically the wall of the ileum is seen to be several times normal in thickness. The mucosa is denuded of epithelium, the muscularis mucosa is fragmented. There is a marked inflammatory infiltration of submucosa and subserosa. The liver showed marked fatty degeneration.

CASE V.—R. L., aged sixty-six, was admitted to the Bronx Hospital in May, 1926. Two months before admission, the patient had been operated on at another hospital for a strangulated right femoral hernia of fifteen hours' duration. At operation the sac was found to contain bloody fluid. The intestine was bluish-black, but the peritoneal lustre was retained. After relief of the constriction, the normal color of the intestine returned and the gut was considered viable and replaced.

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Following her discharge from the hospital, she commenced to have violent abdominal pain accompanied by borborygmus. The pain was most marked two to three hours after meals. She became gradually more constipated. On admission there was distention and visible small intestinal peristalsis. Two months after the original operation a laparotomy was undertaken for incomplete intestinal obstruction. The distal 35 cm. of ileum was found thickened, stenotic and covered with a fibrinous layer. The mesentery was tremendously thickened and contained numerous large hard glands. Grossly the possibility of neoplasm or tuberculosis could not be ruled out.

The involved segment of gut was resected and an ileocolostomy performed. The patient made an uneventful recovery.

The resected specimen is of great interest. The entire resected portion is greatly thickened, the most marked thickening being in the submucosa. The lumen is markedly stenotic. Five mucosal ulcers in various stages of healing are present. The ulcers vary in size from 1 x 3 to 1 x 1 cm. in diameter. The intestinal stenosis is most marked in the region of these ulcers.

Microscopically, there is an inflammatory granulation tissue occupying the submucosal layer. The epithelial lining of the gut has an altered epithelium having lost its normal glandular structure. There is no evidence of tuberculosis, syphilis, actinomycosis, or malignancy.

CONCLUSIONS

1. Following the replacement of badly compromised but viable intestine, symptoms of obstruction may appear after a varying free interval.
2. These symptoms are due to a fibrotic intestinal stenosis resulting from mucosal necrosis, thrombosis of small mesenteric and intramural vessels and infection by organisms from the lumen of the bowel. The stricture may be tubular or annular.
3. The obstruction remains incomplete for a long time.
4. Early operative intervention is necessary and should consist of a short circuiting entero-anastomosis or resection.

Thanks are due to Dr. A. A. Berg for permission to report the cases occurring upon his service. The authors are also indebted to Dr. Edwin Beer for allowing them to incorporate a case observed on his service, in the present article.

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SPONTANEOUS RUPTURE OF SPLEEN WITH VENOUS THROMBOSIS *

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OF CHARLESTON, S. C.

IN CONSIDERATION of the condition of rupture of the spleen it is well to bear in mind that there are certain predisposing factors in the normal spleen, which may become exaggerated in various diseases. In a way it may be thought of as a pulpy bag of blood, loosely attached by a vascular pedicle, and were it not for the protection which is afforded in its position, it would, no doubt, be more frequently ruptured. Even in its normal state it is probably two or more times the size which we are accustomed to give it from postmortem experience, and this difference in size during life is wholly a matter of contained blood. During the process of digestion we know that there is a large engorgement of the organ with blood and this as a predisposing factor has been apparently evident in a number of cases of spontaneous rupture.

In various diseases the blood content of the organ is increased, sometimes remarkably, and intrasplenic hemorrhages of minor degree are relatively frequent in such states. Notable among the diseases in which such engorgement of the organ occurs are typhoid fever and malaria, and spontaneous rupture has occurred in a number of cases of both. In 123 cases of spontaneous rupture collected by Berger² ninety-nine were malarial, while of twenty-eight cases of spontaneous rupture during the course of acute illness collected by Wohl³ fourteen had typhoid fever. Even in traumatic rupture, disease has its influence. In spontaneous rupture engorgement with blood is *the* important factor. In traumatic rupture the important disease factor seems to be enlargement and consequent unusual exposure of the organ to injury, although many enlarged spleens are, at the same time, congested.

Whether spontaneous rupture of the organ in a thoroughly normal state actually occurs may be questioned. The large majority of reports concern organs which have been diseased. Susman¹ was able to collect only seven cases, including one of his own, in which rupture of an apparently normal spleen had occurred.

It is difficult to conceive of a normal organ, even of the construction of the spleen, bursting under physiological conditions. Perhaps those seven apparently normal spleens were not normal at the time and site of the hemorrhage. For instance, it would seem easily possible for a hemorrhage to occur as a result of an infarct, the evidence of which might be destroyed in the rupture. Wohl advances the theory that sclerosis and degeneration of the small arterial blood-vessels may be the foundation for hemorrhage in spon-

* Read before the Southern Surgical Association, December 13, 1927.

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taneous rupture, a sort of splenic apoplexy, so to speak, and the frequency of occurrence of arteriolar sclerosis in the spleen, together with the knowledge which we have of various other "apoplexies" make this a suggestion worthy of consideration, although it would seem, as Susman points out, that if this were more than a subsidiary factor splenic rupture should increase in frequency with age.

Of the seven cases of spontaneous rupture of normal spleens, only two of the subjects may be considered to have been well at the time, four of the others having shown some alimentary tract disorder, one of these gall-stones, and the fifth, pulmonary tuberculosis. All of which point to the conclusion that a normal spleen does not rupture under normal physiological conditions.

CASE REPORT.—The case which I have to add to these records came under my observation in July, 1925. J. N. K., white, male, aged twenty-five years, electrician by occupation. Family history negative. July 26 about 1 P.M., just after finishing dinner, he was seized with sudden sharp pain in the left upper quadrant of the abdomen. Almost immediately he vomited. He then took a dose of "salts." About 6 P.M. he took a bottle of citrate of magnesia but his bowels had not moved at the time of his admission to the hospital, about 4 o'clock the next morning. He had not had malaria or typhoid fever. His only previous illness was influenza (four days' duration) in 1920 and he had been perfectly well until the sudden onset of this pain. Upon admission to the hospital his temperature was 90° F., pulse 80 per minute, respiration 26, shallow. Patient well nourished and developed. His abdomen was moderately distended, there was nothing palpated as abnormal, there was no dullness, peristalsis was active over the entire abdomen. Palpation beneath the left costal border revealed tenderness and rigidity. The entire left upper quadrant was rigid. Pressure over any part of the abdomen and over the left kidney region gave sharp pain in left upper quadrant anteriorly. He had no pain in the left shoulder, such as is recorded in other cases, and his physical examination was otherwise negative. His urine showed a trace of albumin, plus two indican, and an occasional pus cell. Hæmoglobin 85 per cent. (Dare). Leukocytes per c.mm. 13,040. Polymorphonuclear neutrophils 85. On opening his abdomen it was found to contain about 750 c.c. of free blood, including many clots. This was found to be coming from a ragged rent in the outer surface of the spleen. The spleen was removed, blood sponged out of the belly, and the patient was given 750 c.c. of normal saline solution intravenously during the operation. His blood picture continued practically the same, with about 3,000,000 erythrocytes, for the next two days. There then was a steady improvement with gradual return of the red blood corpuscles and hæmoglobin to normal and a reduction of the leukocytosis to about 10,000 during the next twelve days. His recovery was uneventful wound healing by primary union and he left the hospital on the fourteenth day after operation. He resumed his occupation at the end of a month and has remained well since that time. His present physical condition (December 3, 1927)—height 5 feet 8 inches, weight 153¾ pounds, general physical examination negative. Blood examination: Hæmoglobin 86 per cent. (Dare), erythrocytes 3,980,000, leukocytes 11,200, small and large lymphocytes 30, large mononuclears and transitionals 4, polymorphonuclear neutrophils 64, eosinophiles 2, basophiles 0, other varieties 0. Plate-



FIG. 1.—Gross appearance of spleen after removal, showing the point of rupture of the capsule, and foci of hemorrhage in the pulp, from the root to the point of rupture of the capsule on the outer or convex surface. Shape of the spleen is altered by fixative solution.

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let count 280,000. Coagulation time 5 minutes, blood clotting time $2\frac{1}{2}$ minutes. Fragility test normal. Urine normal. Blood pressure (mercury) systolic 130, diastolic 70.

The spleen which was removed was of the normal average size and appearance, except for the rent in the capsule (Fig. 1). This point of rupture was about the middle of the convex surface and within it the blood was clotting. The hemorrhage extended in irregular fashion on through the middle of the organ toward the root. The removed spleen was examined by Dr. Kenneth M. Lynch, and histologically was of normal appearance in so far as the pulp was concerned. The capillaries of the Malpighian body appear



FIG. 2.—Vein of spleen, with surrounding pulp in spontaneous rupture of organ. ($\times 100$.) Clotting of blood within the veins. Seems to be a thrombosis by the irregular distribution of elements of blood but there is no change in the wall and it may have followed the rupture.

somewhat thickened and hyalinized. Toward the root of the organ the veins contained the elements of the blood in such arrangement as to signify a new thrombus, that is, there was a precipitation of the fibrin, and the red blood corpuscles and leukocytes were in irregularly disposed masses instead of being uniformly mixed. This clot was apparently attached to the lining of the vein (Fig. 2). There is no evident reason for thrombosis, there was no change in the walls of the veins, there was no apparent infarction, and the thrombosis, if it really was a thrombosis which antedated the hemorrhage, could not have existed for any length of time prior to the operation.

It remains a question whether this venous thrombosis was the cause of the hemorrhage into the spleen and the subsequent rupture of the capsule, or whether it was merely the subsequent thrombosis occurring in the bleeding vascular tree.

Clinical Features: Except for the history of traumatism there seems to be little or no difference in the clinical picture presented by traumatic and spontaneous rupture of the spleen. The notable tendency of the spontaneous

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occurrence to be related to the engorgement of the organ during digestion seems to be the only feature belonging mainly or exclusively to the latter. Vomiting may or may not happen in either. It is used as a differentiating point by some and is considered rare by others. It seems to have been a prominent symptom in the cases of spontaneous rupture of seemingly normal spleen. Paresis and distention of the intestine has been prominent in some but not in others. Abdominal rigidity, usually marked in traumatic rupture, may not be so pronounced in the spontaneous variety, although it may be. It was extreme in my case. Syncope and shock, commonly pronounced in the traumatic, depend in their prominence upon the severity of the hemorrhage in the spontaneous, as does also the evidence of fluid in the abdomen. Pain in the left shoulder, apparently referred from the subphrenic irritation of the blood below the diaphragm and around the spleen through the cervical cord and to the third and fourth cervical nerve, has been an outstanding symptom in some cases of both kinds, and absent in others.

Traumatic rupture is, to my mind, more readily diagnosed because it is more easily anticipated. Spontaneous rupture occurs out of the blue sky, so to speak, and while it may be diagnosed with considerable certainty in a case presenting a characteristic picture, as long as the condition presented is recognized as an acute abdominal crisis demanding immediate operation, it makes no difference how positive the diagnosis may be. It merely needs to be borne in mind as one of the things which may be encountered, in order that the splenic area may be accessible to the operator.

As to the choice of the repair of the rupture, or removal of the organ, I take it that the latter is recognized as a safer procedure. Of course where it appears that the rent in the capsule may be easily closed and without danger of subsequent rupture one might suture or tampon the organ but it would be difficult to evaluate the probability of further rupture. Undoubtedly in some cases of both kinds of rupture the bursting of the capsule and the intra-abdominal hemorrhage has followed (in some instances at a considerable interval of time) the primary rupture or hemorrhage into the pulp of the organ. With this in mind and a knowledge of the high mortality of the unoperated or postponed, there seems to be little choice in the matter. Whatever the work of the spleen may be, we know that its presence is not necessary to comfortable life and in an emergency of this degree there should be no hesitation on the ground of saving it.

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ANALYSIS OF ONE HUNDRED AND SEVENTY-SIX CASES OF CARCINOMA OF THE STOMACH SUBMITTED TO AUTOPSY

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IN THE files of the Department of Pathology at the University of Minnesota, for the past twenty years, there are reports of 7,800 necropsies with 570 cases of carcinoma, and 176, 2 per cent. of the total, or 30 per cent. of the carcinomas show a primary location in the stomach. This necropsy series includes the examinations made by members and associate members of the pathological staff at various places in the Twin Cities; the Miller, Ancker, and Gillette Hospitals in St. Paul, and in Minneapolis, the University, and the Minneapolis General Hospitals together with coroner's cases and necropsies performed for practicing physicians. The series then, while not a particularly large one, represents a wide range of incidence and provides interesting material for study.

Sex.—As shown in Table I, the greater number, 143 or 81 per cent.,

TABLE I.

Sex.

Males	143.....	81%
Females	33.....	19%

occurred in males with thirty-three or 19 per cent. in females. This does not, of course, represent actual incidence, for in the University files more necropsies (two and five-tenths to one) are performed upon males. But even after correction is made, it is still apparent that the disease occurs more commonly in males. No definite reason for this is offered. Rough diet and irritating food might be considered as an etiological factor in some men, but with these city dwellers, there can be little difference in the diet of the men and the women.

Age.—The age incidence, in Table II, is found to vary widely from thirty-

TABLE II.

Age.

Noted in 171

30-39 years	12.....	7%
40-49 years	33.....	19%
50-59 years	50.....	29%
60-69 years	59.....	35%
70-79 years	14.....	8%
80-89 years	3.....	1.7%

Youngest 32 years

Oldest 82 years

CARCINOMA OF THE STOMACH SUBMITTED TO AUTOPSY

two to eighty-two with an average of fifty-nine years. The highest, 35 per cent., occurs in the sixth decade; the fifth decade plays a close second with 29 per cent.; then comes the fourth decade with 19 per cent., while a definite number (7 per cent.) of the cases occur in the thirties, one at thirty-two. The seventh decade shows about the same number as the third, 8 per cent., as compared to 7 per cent., while the fewest (1.7 per cent.) occur in the eighties. Here again true incidence is not shown since few necropsies are performed upon persons over eighty years of age. A curve showing the age incidence of all the autopsies in the pathological records compared to autopsies on cases

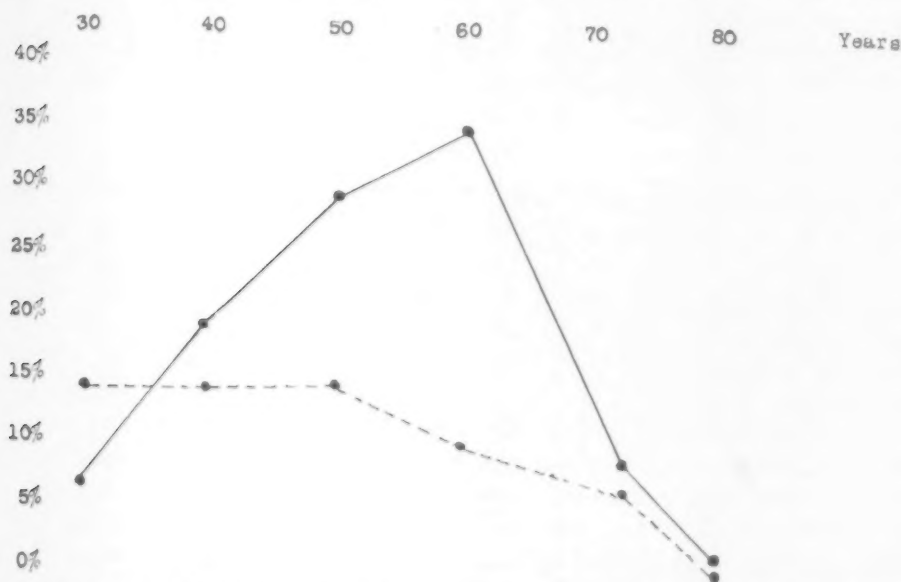


CHART 1.—Age incidence of carcinoma of the stomach, as compared with age incidence of total autopsy series. — Age incidence of carcinoma of stomach. - - - - - Age incidence in total autopsy series.

of carcinoma of the stomach is shown in Chart 1. It will be seen that the highest point of autopsy incidence remains fairly constant at about 15 per cent. until fifty years from where it drops down to less than 1 per cent. at eighty. On the other hand, the age incidence of autopsies of carcinoma of the stomach rises steeply from 11 per cent. at thirty years to 35 per cent. at sixty years, then at seventy years it drops down to the level of the others. Therefore, we see that the age incidence of cases of autopsies upon gastric carcinoma is much higher than that of the entire series. It becomes apparent that in this study carcinoma of the stomach is a disease of middle life usually occurring after fifty, but sometimes appearing before fifty with occasional cases before forty years of age.

Location.—The location of the tumor mass in the stomach wall was described in detail in 175 cases and in Table III there is an attempt at classification which was very difficult of accomplishment because of the few anatomical land marks in the stomach. The favorite location was the pylorus (42

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TABLE III.

Location.

175 Cases

Pylorus	74.....	42.2%
Limited to pylorus.....	41.....	55%
In wall and pylorus	33.....	45%
Wall	65.....	37.0%
Anterior wall	5.....	7.6%
Posterior wall	16.....	24.6%
Not mentioned	44.....	67.7%
Greater curvature	18.....	27.0%
Lesser curvature	25.....	38.0%
Not mentioned	22.....	33.8%
Cardia	19.....	10.8%
Diffuse	17.....	9.7%

per cent.) and of these slightly more than half (55 per cent.) were limited to the pyloric ring while the remainder (45 per cent.) extended up on the wall. The wall itself, somewhere between the cardia and the pylorus, was affected in sixty-five cases or 37 per cent. of the series. Of these five or 8 per cent. were on the anterior wall and sixteen or 24 per cent. were on the posterior wall while the majority (forty-four or 67 per cent.) did not have the exact position designated. The position on either anterior or posterior walls seemed to receive more consideration since only twenty-two or 33 per cent. had no reference to it. The tumor growths were situated on the lesser curvature in twenty-five or 38 per cent., and on the greater curvature in eighteen or 27 per cent. The cardia was the site of the carcinoma in nineteen or 11 per cent. of the cases and there was a marked variation in size here also. The majority of the tumors were limited to the zone directly around the cardia, but some of them extended down upon the wall in an irregular manner difficult to classify.

In seventeen or 10 per cent. the carcinoma appeared as a diffuse growth throughout the wall, resulting in many of the cases, in the so-called "leather bottle" stomach with stiff hard walls and a lumen much decreased in size. Some of them had ulcers at various points and others had cauliflower-like masses projecting from some point on the inner surface. These cases presented practically the same number and location of metastases as did the others in the series. It is of interest, however, to see that six, or one-third, had an obstruction which seemed to be the fatal factor, so it appears that in diffuse carcinoma of the wall, obstruction has a slightly higher incidence than localized carcinoma of the wall, but not as high as carcinoma of either the cardia or the pylorus.

Ulceration.—Ulceration is an expected early complication of carcinoma of the stomach, because the new growth, which is more or less bulky, carries comparatively few blood-vessels and is constantly subjected to the digestive action of the gastric juice. But, as is shown in Table IV, ulceration was present in less than half of the carcinomas of this series (43 per cent.) according to the

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TABLE IV.

Ulceration.

Present.....	76	43.4%
Perforated.....	39	32.0%

(51% of ulcers).

gross examination. Doubtless microscopic examination would have shown a more frequent loss of surface tissue. The ulceration observed varied from an absence of superficial epithelium to complete loss of stomach wall, causing perforation. Definite gross perforation was found in thirty-nine which represents 22 per cent. of the entire series, and 51 per cent. (more than half) of the ulcerated cases. This opening in twelve cases, representing 30 per cent. of the perforated cases, 16 per cent. of the ulcerated cases, and 7 per cent. of the total series, was plugged by adjoining structures such as pancreas, liver, lymph-nodes and fibrous adhesions, and consequently there was no resulting peritonitis. But in twenty-seven, which represented 70 per cent. of the perforated cases, 35 per cent. of the ulcerated cases, and 15 per cent. of the entire series, there was a direct communication between the lumen of the stomach and the peritoneal cavity resulting in the peritonitis which proved fatal.

Obstruction.—Obstruction is a common and early complication of gastric carcinoma and usually results in the symptoms which bring the patient to a physician and necessitates operative interference. In this series, as shown in Table V, fifty-nine or 34 per cent. showed definite obstruction. This obstruc-

TABLE V.

Obstruction.

Obstruction.....	59	34%
Cardia.....	19	11%
Pylorus.....	42	24%

tion was present in the pylorus in forty-two which represents 72 per cent. of the cases of obstruction; 56 per cent. of the cases of carcinoma of the pylorus; and 24 per cent. of the entire series. It was present in the cardia in nineteen which represents 32 per cent. of the cases with obstruction, 100 per cent. of the carcinomas of the cardia and 11 per cent. of the entire series. In two cases with diffuse carcinoma, it was present in both. Therefore, obstruction always occurs with carcinoma of the cardia and usually with carcinoma of the pylorus. The degree of obstruction is difficult to determine for there is no accurate method of measuring it and in very few instances was the degree definitely mentioned. Furthermore, the anatomic obstruction is not always the same as functional obstruction, and a patent passage through a very stiff walled and rigid pylorus may give much more clinical evidence of obstruction than a large, polypoid, soft mass which appears to entirely fill the lumen of a pylorus with soft walls.

Metastases.—Since the significance of all carcinomas lies, not only in the primary growth in one organ but also in the secondary growths which may appear

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in other parts of the body and interfere with vital processes, the metastatic growths in this series will merit consideration and are shown in Table VI. As would be expected, the majority (78 per cent.) showed secondary growths in other parts of the body, but it is of interest to find that nearly a fourth (23

TABLE VI.

Metastases.

Liver.....	67	38%
Perigastric nodes.....	63	36%
Retroperitoneal nodes.....	51	28%
No metastases.....	40	23%
Peritoneum.....	35	20%
Omentum.....	24	13%
Lungs.....	21	12%
Mesentery.....	15	9%
Bronchial nodes.....	19	9%
Mesenteric.....	15	9%
Pleura.....	14	8%
Pancreas.....	13	7%
Adrenals.....	8	5%
Intestines.....	7	4%
Kidney.....	6	3%
Diaphragm.....	4	2%
Spleen.....	4	2%
Gall-bladder.....	4	2%
Bladder.....	3	2%
Ribs.....	3	2%
Uterus.....	2	1%
Ovaries.....	2	1%
Brain.....	2	1%
Vertebrae.....	1	6%
Prostate.....	1	6%

per cent.) came to autopsy with only the original, primary tumor growth of the stomach. The liver was the favorite site for metastases, being affected in 38 per cent. of the cases, while the regional lymph-nodes around the stomach played a close second with 36 per cent., and then came the retroperitoneal lymph-nodes (28 per cent.), peritoneum (30 per cent.), omentum (13 per cent.), and mesentery (9 per cent.). Carcinoma was found in the pancreas, as well as the stomach, in 7 per cent. of the cases, but in an organ situated so near the stomach, it is impossible to distinguish true metastasis from growth continuity when the condition has reached a terminal stage. Metastatic growths were found in the lungs in 12 per cent., the pleura in 8 per cent., and the bronchial lymph-nodes in 9 per cent.

The spleen is usually an infrequent site for secondary carcinomas and this is borne out by this series where they were present in only four cases or 2 per cent. of the series. The remainder of the table proves that secondary growths may appear in any part of the body, although they are usually present in the liver, lymph-nodes, peritoneum, omentum, lungs or pleura.

The forty cases (23 per cent.) which showed no secondary growths pre-

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sent an interesting study in themselves. The question is at once raised whether death occurred from some intercurrent cause or complication before secondary growths had time to develop, or whether the absence of metastases was due to some inherent characteristic in either the individual tumor or in the host. The clinical histories, taken as they were, by various people at various places show no standardization and are of little value in estimating the duration of the disease. Furthermore, the first symptoms do not always give accurate evidence of the appearance of the tumor, for different carcinomas of the stomach present very different clinical pictures because of the wide variety of symptoms which are caused by the location in different parts of the organ. Some of the tumors may grow to a very large size on the wall before causing symptoms, while other very small ones in the pylorus may early cause obstruction which necessitates operative interference or causes death from malnutrition. Therefore, the duration of the tumor growth offers little to explain the absence of metastases. The major complications causing death are shown in Table VII and prove that these patients did not die from intercurrent diseases before secondary growths developed. Almost one-half (45 per cent.) died from

TABLE VII.

Causes of Death in Cases with no Metastases.

40 Cases

Peritonitis.....	18 or 45	%
Post-operative.....	9 "	22 %
Perforation.....	9 "	22 %
Obstruction.....	5 "	12 %
Operative shock.....	4 "	10 %
Hemorrhage.....	3 "	8 %
Severe anemia.....	2 "	5 %
Endocarditis.....	2 "	5 %
Meningitis (Pneumococcic).....	1 "	2.5 %
Suicide.....	1 "	2.5 %
Encephalomalacia.....	1 "	2.5 %
Broncho-pneumonia.....	1 "	2.5 %
Pulmonary abscess.....	1 "	2.5 %
No cause known.....	1 "	2.5 %

peritonitis and in half of these or nearly a fourth (22 per cent.) the peritonitis was the result of perforation by ulceration of the tumor indicating that it must have been present for a sufficient length of time to have extended entirely through the stomach wall. Obstruction, hemorrhage and severe anemia were the cause of the death of another fourth of the series and all of these indicate a development of fairly long standing. Eight more died from operative shock and one is justified in thinking that operation would not have been undertaken unless the tumor was causing definite symptoms. Only eight or 20 per cent. died from causes which might have been considered as intercurrent or having no relation to the tumor in the stomach. A comparison of Table VII with

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Table VIII, in which are shown the diseases or fatal complications causing death in the entire series, shows that they are not very different, and there is no evidence of the cases without metastases dying before secondary growths could develop. Therefore, it seems that the failure to produce metastases must be an inherent characteristic of either the host or of the tumor itself.

TABLE VIII.

Causes of Death.

176 Cases

Peritonitis.....	45	26	%
Post-operative.....	18	10	%
Perforative.....	27	15	%
Obstruction.....	34	19	%
Broncho-pneumonia.....	13	7	%
Gastric hemorrhage.....	12	7	%
Operative shock.....	10	6	%
Severe anemia.....	9	5	%
Obstructive jaundice.....	9	5	%
Pulmonary tuberculosis.....	3	2	%
Myocardial failure.....	3	2	%
Coronary sclerosis.....	3	2	%
Intestinal obstruction.....	2	1	%
Abscess of liver.....	2	1	%
Meningitis.....	1	.5	%
Pulmonary abscess.....	1	.5	%
Lobar pneumonia.....	1	.5	%
Acute cystitis.....	1	.5	%
Bacterial endocarditis.....	1	.5	%
Retrocaecal abscess.....	1	.5	%
Septicæmia.....	1	.5	%
Suicide.....	1	.5	%
Addison's disease.....	1	.5	%
Encephalomalacia.....	1	.5	%
Thrombosis of inferior vena cava.....	1	.5	%
Metastatic brain tumor.....	1	.5	%
Carcinoma alone.....	19	11	%

Fatal Complications.—It is of interest to know just why each one of these patients with carcinoma of the stomach died. Does the mere presence of the tumor in the stomach cause emaciation and death from the so-called "cancer cachexia"; does the new growth interfere with the digestive process and cause death from malnutrition; do the secondary tumors in other parts of the body interfere with vital processes and cause death in that way; or does some intercurrent disease attack the person already debilitated by the growth of the carcinoma, and cause death by means which would not have proved fatal in normal persons? The major fatal complications of the cases in this series are shown in Table VIII. Of these nineteen or 11 per cent. showed no complications and no cause for death other than the presence of the tumor. Many of these had bulky metastases in the liver, but the possibility of death from liver insufficiency could not be proved by the autopsy. The most common fatal

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complication was peritonitis which occurred in forty-five cases (26 per cent.), and the cause of this was equally divided between operative interference and perforation of the wall by ulceration of the tumor growth. The first impression, then, would be that one stood an equal chance of death from peritonitis in being operated upon or in letting the tumor take its course, but one should remember that the chances of death from perforation are equal to the fatal cases following operation and that many cases are successfully operated upon and do not appear in these statistics. Next to perforation comes obstruction (19 per cent.) and this number would doubtless be much greater if many with obstructive symptoms had not been operated upon, and either not appear here at all or else be listed under some fatal post-operative complication such as shock or peritonitis.

The next most common fatal complication is broncho-pneumonia and it is a debatable question whether this is a true intercurrent infection or whether it is a complication of carcinoma, developing in persons already debilitated by the presence of a tumor in the most important digestive organ. It is quite true that primary, fatal broncho-pneumonia is rare in an adult, but it is also true that many of these patients were well nourished and not yet showing any evidence of harm done by the carcinoma. Massive hemorrhage claimed 7 per cent.; severe anemia from constant oozing 5 per cent.; operative shock, 6 per cent.; and obstructive jaundice from encroachment of the new growth upon the bile ducts, 5 per cent. Then follows a long list of diseases which are apparently intercurrent. Upon reviewing this table, summing up the fatal complications, and classifying them according to intercurrent causes of death or as complications due to the presence of the tumor itself, it becomes apparent that the great majority (69 per cent.) die from complications directly referable to the growth of the tumor, while 20 per cent. die from intercurrent diseases; and complications are entirely absent in 11 per cent. Therefore, in the great majority of the cases (89 per cent.) death was due to some definite cause and not to the old "cancer cachexia" which is, in all probability, only the result of the malnutrition caused by the presence of a tumor growth in the digestive tract. Furthermore, in spite of the presence of this new growth in the most important of the digestive organs, all of the patients were not emaciated; in fact 18 per cent. were unusually well nourished.

Emaciation.—The relationship of emaciation to carcinoma is too old a question to be dismissed without an analysis of this series in regard to that issue. As seen in Table IX emaciation was prominent in the great majority

TABLE IX.

Emaciation.

Marked.....	110	62%
Moderate.....	35	20%
Not present.....	31	18%

of the cases, 110 or 62 per cent.; it was moderate in thirty-five or 20 per cent. and entirely absent in thirty-one or 18 per cent. "Cancer cachexia" is sup-

posed to be an accepted thing, but here are thirty-one cases, 18 per cent., almost a fifth, which come to autopsy without any demonstrable emaciation. To be sure some of these had lost some weight, but yet at the autopsy they were still well nourished. For example one large man had lost forty pounds and yet at the time of his death was obese, weighing over 200 pounds. In the face of these observations one cannot say that carcinoma always causes emaciation even though it does affect an important digestive organ. The first supposition would be that death had been caused by some intercurrent disease or complication before the tumor had been present long enough to cause emaciation. However, in Table X are shown the causes of death in the cases without

TABLE X.
Causes of Death with No Emaciation.

Peritonitis.....	9 or 29	%
From perforation.....	5 "	16 %
Post-operative.....	4 "	13 %
Hemorrhage.....	5 "	16 %
Obstruction.....	3 "	9.6 %
Anemia.....	2 "	6.4 %
Obstructive jaundice.....	2 "	6.4 %
Broncho-pneumonia.....	2 "	6.4 %
Endocarditis.....	1 "	3.2 %
Suicide.....	1 "	3.2 %
Retrocæcal abscess.....	1 "	3.2 %
Pulmonary tuberculosis.....	1 "	3.2 %
Carcinoma alone.....	2 "	6.4 %

emaciation and they are practically the same as those in the total series. In a comparison of Tables VIII and X it is seen that in both peritonitis leads, and its etiology is equally divided between the causes of perforation and operation. In Table X next comes death from hemorrhage with an incidence of 16 per cent. When 16 per cent. die from perforation, causing peritonitis, and 16 per cent. from hemorrhage from ulceration of the new growth, it is evident that 32 per cent. have died directly from the growth of the tumor even though no emaciation is present. As would be expected, obstruction was a much less prominent complication than in the total series (9.6 per cent.) as compared to 19 per cent.). It is somewhat surprising to note that there were three cases of obstruction without notable emaciation; but in all of these the obstruction was of comparatively short duration. Even though it was very severe and the patients had lost some weight, they were well nourished at the time of their death. The cases dying without any demonstrable complications were much fewer than in the total series, two or 6 per cent. as compared to nineteen or 11 per cent. Another point against the hypothesis of intercurrent death accounting for the lack of emaciation is the presence of metastases in these cases, which were found in twenty-three or 74 per cent. while only eight or 26 per cent. remained primary in the stomach as shown in Table XI. Furthermore when one compares this table with Table VI showing the metastases in the total series, one finds that they are very similar for in the total series 23

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TABLE XI.

Metastases with No Emaciation.

Liver.....	12	38.7%
Perigastric nodes.....	7	19.3%
Retroperitoneal nodes.....	8	25.8%
Peritoneum.....	4	12.8%
Omentum.....	3	9.6%
Pleura.....	1	3.2%
Mesentery.....	1	3.2%
Cerebellum.....	1	3.2%
Lung.....	1	3.2%
Ovaries.....	2	6.4%
Mesenteric nodes.....	1	3.2%
Mediastinal nodes.....	1	3.2%

per cent. remained primary in the stomach. Therefore, in spite of the well nourished condition of the patients one must conclude that the tumor had been present for some time. A very small number, eight or 5 per cent., died without either emaciation or metastases and the supposition would be that these had died from some intercurrent disease occurring early in the cancer development, but this was not the case. The causes of death in these cases are shown in Table XII and one finds that three died from peritonitis following

TABLE XII.

Causes of Death with No Emaciation and No Metastases.

Endocarditis.....	1
Anemia.....	1
Hemorrhage.....	2
Peritonitis (Post-operative).....	3
Myocardial failure.....	1

operation, indicating that the tumor had attained size enough to justify operative interference. Two more died with massive hemorrhage and another with severe anemia which presupposes a tumor of some duration. The remaining two died from heart complications, endocarditis and myocarditis respectively, and these (one-fourth) are all that died from intercurrent diseases having no relationship to the growth. From this series, then, since in one-third (35 per cent.) emaciation was not marked and in 18 per cent. it was not even present, it appears that "cancer cachexia" is not always present and that death, instead of being caused by the "wasting away" usually attributed to cancer cases, is usually due to major complications most frequently dependent upon the presence of the tumor itself and interfering with the vital processes of the body.

SUMMARY

1. This is a study of 176 cases of carcinoma of the stomach taken from the autopsy records of the Department of Pathology at the University of Minnesota.

2. Carcinoma of the stomach occurred more frequently in males than in females.

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3. The age incidence varied from thirty-two to eighty-two with an average of fifty-nine years. The largest number (35 per cent.) occurred in the sixth decade with 29 per cent. in the fifth decade.

4. The most frequent location was in the pylorus (42 per cent.); then the wall (37 per cent.), the cardia (11 per cent.) and diffuse throughout the wall (10 per cent.).

5. Ulceration was present in 43 per cent. and of these 51 per cent. showed perforation which was plugged in 16 per cent. and open, causing a fatal peritonitis, in 35 per cent.

6. Obstruction was definite in 34 per cent. of which 72 per cent. were at the pylorus and 28 per cent. at the cardia.

7. Metastases occurred in 77 per cent. and were absent in 23 per cent. The most frequent site was the liver, then regional lymph-nodes, peritoneum, omentum, lungs, mesentery, and bronchial lymph-nodes.

8. The most frequent fatal complication was peritonitis, the etiology of which was evenly divided between perforation and operation. In 11 per cent. there was nothing but the presence of the tumor to account for death.

9. Emaciation was entirely absent in 18 per cent., moderate in 20 per cent., and prominent in 62 per cent.

AN EXPERIMENTAL STUDY OF ARTERIAL COLLATERAL CIRCULATION

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IN RECENT years the knowledge of the surgery of the large vessels has been greatly increased by the contributions of Halsted, Matas, Carrel, Jaeger, and others. The treatment of vascular diseases has been improved. There is an increasing tendency on the part of the surgeon, to attack the diseased vascular system in all locations. In view of this trend of events, it becomes necessary to enlarge our knowledge of the behavior of the great vessels following manipulations. Much attention has been given the collateral channels developed after ligation of arteries. This is as it should be, for blood must have pathways through which to circulate. The technic of arterial suture has been perfected and the effect of a ligature upon the arterial wall has been studied. Finally, it has long been known that arterial ligation results in atrophy of the parent trunk from the first proximal to the first distal branch. Beyond these observations, little has been done to demonstrate the reaction of the vessels to surgical procedures. It was considered that, in view of the increasing importance of this realm of surgery, further inquiry should be made into the natural response of the organism to alterations in the circulatory bed. It was conceived that this might best be done by a study of the constituents of the vascular tree in an extremity. Consequently, experiments were conducted to observe the rôle played by the main trunk, the lateral branches and the vasa vasorum. The function of each of these channels in the development of a collateral circulation was especially emphasized since, after arterial occlusion, the viability of peripheral parts depends upon the efficiency of the collaterals.

The Main Arterial Trunk.—In order to determine the necessity of the main arterial channel, the femoral artery was excised from the inguinal ligament to its termination in the popliteal space.

Through a long incision on the inner surface of the leg the artery was isolated and lifted from its bed. It was divided between ligatures at its point of emergence beneath the inguinal ligament. The large branches were dissected out about one inch lateral to the parent trunk and divided. The femoral artery was dissected out in this manner to the point of its division in the popliteal space. The dissection was continued to include the popliteal artery. The tibial and peroneal arteries were isolated and were then drawn up as far as possible, ligated, and divided. Care was taken to avoid the vein and nerve, and muscles were separated along their fascial planes rather than cut. The wound was closed in layers with silk.

Six dogs were operated upon in this manner. In no instance did gangrene occur. Due, no doubt, to the extensive dissection, the leg was slightly tender for a few days. After this time the animal walked upon the limb with ease and without apparent fatigue.

If, in two weeks, the vascular system is visualized by a röntgenogram after injection with Hill's opaque mass³ a marked dissimilarity between the



FIG. 1.—The dilated anastomotic vessels observed two weeks after excision of the femoral artery and its terminal branches. (Side opposite marker.)

normal and operated extremity is seen. This is shown by Figure 1. It will be observed that in the limb deprived of the femoral artery and its terminal branches, there is an amazing increase in the vascular network. The richness of this circulatory bed is the manifestation of the compensatory act. The small vessels have taken over the function of the parent trunk. That they do this adequately is testified by the absence of gangrene or functional disability. Sections of the semimembranosus muscle were taken from the two limbs and stained with Weigert's elastic tissue stain and with hæmatoxylin and eosin. (From a study of these specimens

it was determined that the increased vascularity of the operated extremity was due to a dilatation of preëxisting vessels. There was no evidence of the formation of new arteries. The arteries on the operated side were much larger than those in a comparable location in the normal limb.)

Thus, the main vascular trunk in this location is not essential for viability and function of the extremity. In the absence of the parent artery, the small, preëxisting branches dilate to form a rich vascular plexus on the affected side.

In the dog, blood is supplied to these small arteries from the profunda femoris, the hypogastric, especially the parietal branch, the external circumflex femoris and the anterior femoris arteries.

The Lateral Branches.—It has been known since the time of Gooch¹ that after occlusion of an artery it atrophies from its first proximal to its first

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distal branch. This has been substantiated by Jones,⁴ Stilling,¹⁰ Raab,⁸ Warren,¹¹ Halsted,² and Reichert.⁹ The importance of the lateral branches in maintaining the viability of the parent trunk is obvious. It was decided to determine the behavior of the main artery and its branches if segments were ligated without any branch and also with one, two, three or four branches. In this way information could be obtained on the importance of the lateral branches as collateral channels after ligation of the main artery.

Twelve dogs were operated upon. The femoral artery of one or both sides was exposed, and beginning below the profunda branch, ligatures were placed at intervals to the point of division of the channel. These ligatures were so placed as to include segments without lateral branches as well as isolated portions having one, two, three or four branches leading from them. Silk was used throughout. In many of the animals silver clips were placed at the site of the ligature for visualization with the X-ray. Healing was uneventful and within a few days the animal used the limb freely. There was no instance of gangrene.

The blood pressure in a segment having one or more lateral branches rises rapidly. If the immediate effect is obtained, in an animal whose femoral pressure, measured in mm. Hg., is 176 it is found to fall to 32 and to return to 92 in ten minutes. At the end of forty-eight hours the pressure is 104 and in ten days has reached 124. This is shown in Figure 2. In the arterial segments without branches there is never pressure.

The end result of such isolated portions is important. In Figure 3 is shown all of the different preparations in an animal fourteen weeks after operation. It is noted that both segments isolated without branches have atrophied. The portion of femoral artery having one branch between ligatures has been greatly reduced in size, but the lumen near the branch is patent for it has partially filled with the injection fluid. An isolated segment having two branches is, perhaps, the most interesting. Here it is found that the main artery has atrophied between the ligatures and the branches while that part between the branches has become smaller. It appears that the arterial trunk is

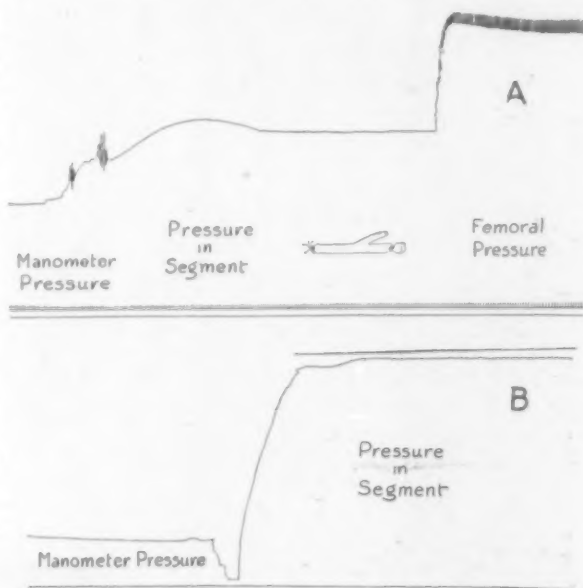


FIG. 2.—The blood pressure in an isolated segment of artery having one branch. A. Forty-eight hours and B ten days after operation.

becoming an integral part of a smaller artery, which now consists of a branch in which the current must be reversed, the main artery between the branches, and a branch in which the direction of flow is unchanged. A segment of artery which has three or more branches leading from it atrophies between the ligature and the first branch and then resumes its normal calibre.

It is found, therefore, that one or two lateral branches prevent total atrophy of the parent trunk after its double ligation and with more than two branches the main artery is unchanged.

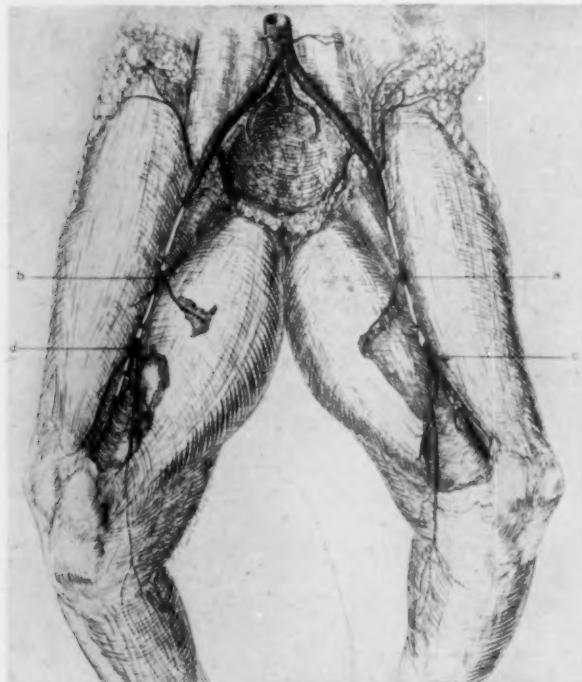


FIG. 3.—The result of isolated segments fourteen weeks after operation. The first segments have no branch. a. Shows a one branch segment with the branch and lumen filled. b. Illustrates a two branch segment. c. and d. Are three and four branch segments respectively.

Vasa Vasorum.—The part played by the vasa vasorum as collateral channels has long been a debated question. The drawings of Porta⁷ portray, after ligation of the aorta, small anastomotic vessels which are not named but which appear to be vasa vasorum. They were so considered until Reichert's⁸ careful work showed them to be new formed vessels. This does not prove, however, that these small vessels may not act as collateral channels. Lewis and Reichert⁶ have demonstrated that throm-

bo-angiitis obliterans differs from arteriosclerosis in having an extensive collateral circulation and Lewis believes the presence of the vasa vasorum is partially responsible for the result. It would be desirable, therefore, to settle the long debated question of the possibility of the vasa vasorum acting as collateral channels. The simplest method would be to show that these nutrient vessels passed around an obstructing ligature placed on the parent artery. This has been accomplished.

On undertaking this problem, a survey of the literature revealed that (1) there was no adequate anatomical description of the vasa vasorum (2) there was no method of injecting these vessels. Perhaps the best description is to be found in Kölliker's *Anatomic*.⁵ After some experimentation it was found that, if a 2 per cent. aqueous Prussian blue solution was injected into the lumen of a branchless segment of artery, the vasa vasorum would fill. The carotid is the most convenient artery for the purpose. A cannula is placed

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in the lumen at a point low in the neck, the blood is gently expressed from the artery, and with minimum dissection a ligature is placed just proximal to the next branch. This gives a branchless segment of approximately three inches. Injection is carried out at 180 mm. Hg. for five minutes or until the vasa vasorum are well filled. The specimen is removed and placed in formalin. The next day the lumen is opened and the excess dye removed. The specimen can then be sectioned, dissected or cleared for study.

Observations were made on the mode of origin, anastomosis and destination of the vasa vasorum which revealed the inadequacy of the previous description. When the work had reached this stage an article by Woodruff¹² appeared on the subject giving data obtained from the aorta of the horse and dog, which adequately supplied the deficient information. Consequently, no attempt will be made to duplicate this description, it being sufficient to state that this independent work on the carotid substantiates in every respect the findings of Woodruff on the aorta.

If the vasa vasorum are injected within twenty-four hours, after ligation of the carotid artery they do not cross the ligature. However, they are found to have an amazing anastomosis with the small arteries of the surrounding tissue and by this means the vasa vasorum on the distal side of the ligature fill with the dye. Later, the vasa vasorum destroyed at the time of ligation, regenerate and pass over the ligature. Thus, there are two sets of vessels passing around the obstruction, those which are vasa vasorum proper and those which anastomose with the vasa vasorum and after traveling out into the surrounding tissue return to them. This is shown in Figure 4. (That these small vessels actually are collateral channels is shown by the fact that if the lumen is opened distal to the ligature during the process of injection the dye will flow from it.)

Thus, it is shown that the vasa vasorum may act as collateral circulatory channels after arterial ligation.)

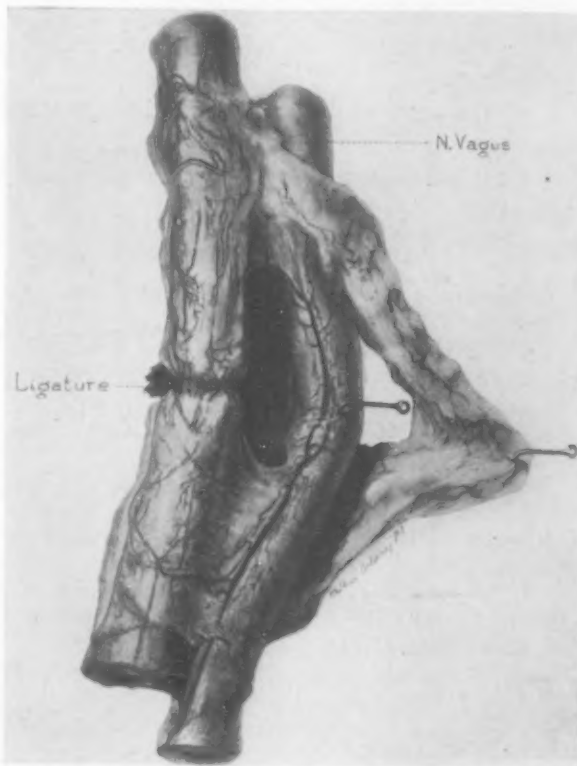


FIG. 4.—The anastomosis of the vasa vasorum above and around a ligature on the main artery.

SUMMARY

1. The main artery of an extremity may be completely excised without subsequent gangrene or functional disability.
2. The removal of the principal artery is compensated for by the dilatation of the smaller vessels which results in a rich vascular plexus.
3. One or two lateral branches seem to prevent total atrophy of a segment of artery isolated between ligatures.
4. Three or more branches preserve unchanged an isolated portion of the parent artery.
5. The vasa vasorum pass around a ligature obstructing their parent artery and so act as collateral channels.

I am indebted to Dr. Dean Lewis for many helpful suggestions during this work.

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TEMPERATURE EFFECT OF POPLITEAL VEIN LIGATION IN THROMBO-ANGIITIS OBLITERANS AND ARTERIOSCLEROSIS

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IN RECENT years it has been well established by both clinical and experimental evidence that ligation of a large artery should be accompanied by ligation of its companion vein, for it has been demonstrated that this procedure results in a diminution in gangrene and an increase in functional ability.^{1, 2, 3, 4, 7, 10, 11, 12} It has further been shown that this results in (a) an increase in residual arterial pressure,^{5, 2, 4, 9} (b) an increase in the venous pressure,¹ (c) an increase in the minute volume flow from the end of the divided artery⁴ and (d) an increase in the peripheral arterial circulatory bed.⁹ It is probable also that it increases the capillary circulation but direct evidence on this point is lacking. It is easily seen, therefore, why ligation of the companion vein, after arterial occlusion, diminishes the incidence of gangrene since it so materially improves the mechanics of the circulation.

It was reasoned that, if after arterial ligation, gangrene could be prevented by occlusion of the vein then it might be equally true that impending gangrene from arterial disease could be avoided by vein ligation. It is realized that in the first instance there is a sudden, complete occlusion of the artery in one location while in the latter case there is a gradual, more generalized constriction of the lumen but the same mechanical factor of reduced peripheral arterial blood is present in each. Consequently it is reasonable to suppose that since there is improvement in the one instance, there should be some benefit in the other.

The analogy appeared to hold and it was decided to ligate the popliteal vein in cases with circulatory deficiency of the extremity, such as arteriosclerosis and thrombo-angiitis obliterans. This has been done in a few instances and it has been found to relieve pain, to increase the temperature of the limb and apparently to increase the peripheral circulation. The number of cases is too small and the time elapsing since operation too short to properly evaluate this procedure. It is not intended at this time to propose it as a method of treatment of vascular disease but it is desired to record the changes in the temperature of the extremity following popliteal vein ligation.

When this procedure was first carried out it was thought that there was no precedent in the matter but it was later found that Oppel⁸ had previously done this operation in six cases.

METHOD

Skin or surface temperature was determined by the surface thermometer shown in Fig. 1. This instrument is of an aneroid type used years ago and is calibrated in Centigrade and Fahrenheit scales.* It is made to register by placing it firmly against the skin for about three minutes. This instrument, old fashioned as it is, was found to be the most satisfactory means of determining surface temperature.

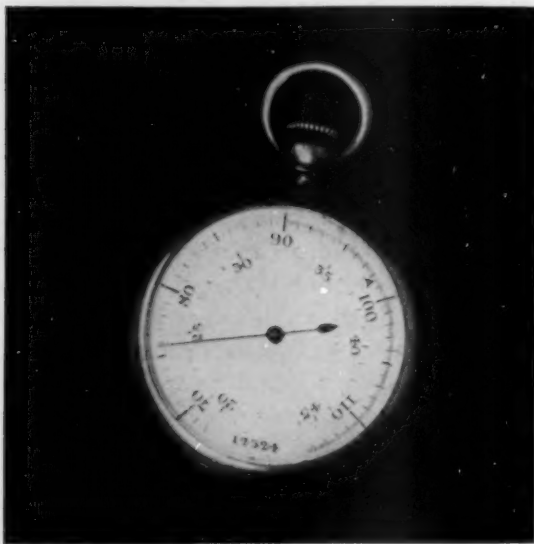


FIG. 1.—Aneroid type of thermometer with which the surface temperatures were registered.

It was desirable, also to ascertain the temperature of the deeper structures and this was done by the thermo-couple galvanometer shown in Fig. 2.† This instrument consists of a "hot" junction of copper and constantan wire fused in the point of a needle with a similar "cold" or constant junction in the thermos bottle. The difference in temperature between these junctions produces a current which is measured by a microammeter and is interpolated into degrees of temperature by calibration of the instrument.

Ordinarily these thermo-couple junctions were inserted into the base of the gastrocnemius muscle for determination of the temperature of the deeper tissues.

In all instances the temperature of the operated extremity was compared with the temperature of the same location on the opposite side. When the temperature of a limb is spoken of as being elevated it is meant in reference to the same location on the opposite member.

CASE REPORTS

CASE I.—P. B., No. 8167, male, Jew, forty-one years, admitted June 21, 1927. The patient had been told he had diabetes but no evidence of this disease was found. Five months before admission he developed gangrene of the right foot with spontaneous amputation of the great toe. Four months before admission gangrene of the left foot appeared. There was claudication with exertion before onset and rest pain after the appearance of gangrene.

Physical Examination.—General examination essentially negative except for extremities; blood pressure 110/70; white blood-cells 8,300; haemoglobin 85 per cent.; Wassermann negative. *Extremities.*—There has been a spontaneous amputation of the right great toe and parts of the other toes of the right foot. There is a discharging sinus over

* This thermometer is the property of Dr. W. J. M. Scott and was used by his grandfather in practice.

† This instrument was made by Dr. Stafford Warren. We are indebted to him for its use.

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the metatarsal phalangeal joint of the left great toe and the skin is dusky. The pulsations of the popliteal, dorsalis pedis and posterior tibial arteries are impalpable on both legs: Urine: Sugar negative. Blood sugar 109.2 mg. per 100 c.c. N.P.N. 26.9 mg. per 100 c.c. X-ray shows calcification of the vessels of both legs.

Impression: Thrombo-angiitis obliterans. Amputation advised and refused.

June 28, 1927, ligation left popliteal vein (The popliteal artery was pulsating).

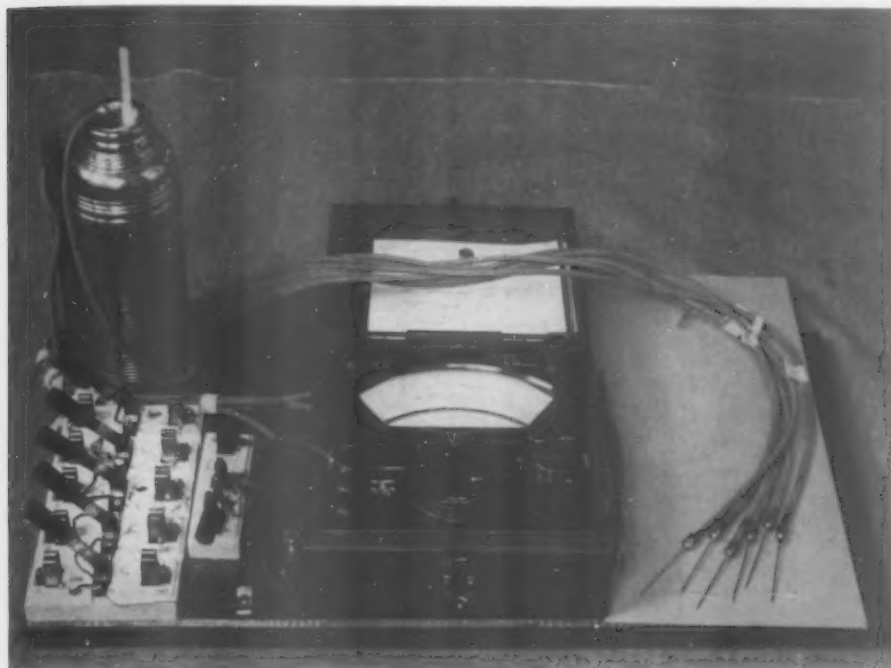


FIG. 2.—Thermo-couple galvanometer, consisting of six hot junctions in the needles connected to a cold junction in the constant temperature "Thermos" bottle. Each thermo-couple is controlled by a switch which connects it to the microammeter.

Temperature changes—	Left	Right
Before operation	86° F.	
½ hour after operation	88.7	87.5
4 hrs. after operation	88.7	87
1 day after operation	90.7	88.2
2 days after operation	91.6	89.6
10 days after operation	88	85.5
24 days after operation	85	83

This difference in temperature was easily made out by a number of observers; subjectively it was also appreciated by the patient.

CASE II.—I. G., No. 9567, male, Jew, fifty years. The patient has had diabetes for thirteen years with loss of thirty-six pounds in weight. Eight months before admission began having cramps in the left leg with exercise. There developed similar symptoms in the right leg four weeks before admission. The condition progressed rapidly especially in the right limb and claudication appeared after walking a few yards and rest pain developed that required morphia for relief.

Physical Examination.—The patient is an emaciated, middle-aged man in extreme pain. There is retinal scarring, tortuous, sclerotic, peripheral arteries, an undescended testicle, left, a right indirect inguinal hernia and a moderate amount of benign pros-

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tatic hypertrophy. *Extremities.*—Both legs are pale and cold below the knee with imperceptible pulsation in the arteries. There are brown scars over the tibiae and over both heels. The sensation of the legs is diminished, motion is limited and the reflexes are absent. The right foot is a reddish-purple in color with frank gangrene of the toes and blebs at the ankle.

Course.—Amputation advised and accepted. September 12, 1927, mid-thigh amputation. At operation all the vessels were sclerosed and tissues boggy. September 22, 1927, gangrene of stump developed. October 18, the right femoral vein ligated. Slight œdema of the stump for two weeks, after which the œdema subsided and the wound healed by granulation. Discharged December 22, 1927. Electrodes inserted before operation. Ligation of right femoral and great saphenous veins (femoral artery pulsating).

At Operation—Deep Temperature.

Time	Right	Left
10.32	90.7	93.8
10.33	91.0 —Femoral ligation	94.0
10.37	90.13	94.2
10.39	90.26 —Saphenous ligation	93.8
10.44	90.39	93.8
10.48	90.26	93.8
10.53	90.26	93.8
10.58 ..	90.26	93.8
11.03	90.8	93.4
11.08	91.82	94.8
11.13	93.0	94.8
11.19	93.2	95.0
11.22	93.0	95.0

Temperature Changes.

	Right	Left
1 day after operation	91.0	89.0
3 days after operation	91.6	89.3
3 days after operation	101.5	95.7
6 days after operation	90.8	89.8
8 days after operation	90.8	90.0
10 days after operation	91.8	91.0
15 days after operation	91.0	89.6
28 days after operation	90.2	91.0

CASE III.—M. S., No. 9845, female, fifty-four years, admitted September 17, 1927. The patient has had diabetes for fourteen years. In November, 1926, she trimmed a callus on the left great toe with a razor and a running sore developed and has persisted. September 11, 1927, ulcers developed in the second and third toes of the right foot. She has had no claudication and very little pain in the feet.

Physical Examination.—An obese woman of fifty-four years with hypertrophied tonsils and slight emphysema of the chest. *Extremities.*—There is redness and swelling of the toes of both feet with œdema on the dorsum of the right foot. The dorsalis pedis and posterior tibial arteries are palpable and there is no calcification of the vessels seen in X-rays. On the right there is frank gangrene of the second and third toes with infection extending up the flexor tendon sheaths. There is an ulcer on the medial surface of the left great toe with a subcutaneous abscess on the plantar surface of the foot.

Impression.—Diabetes mellitus with infection of the left foot and gangrene of the right second and third toes.

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Amputation advised and refused and patient given palliative treatment. The infection of the left foot subsided while the gangrene of the right foot progressed. October 14, 1927.—Ligation of right popliteal vein, excision wedge of second and third toes right (strong pulsation of popliteal artery).

Course.—The wound in the popliteal space healed by first intention and the wound in the foot granulated and healed in three weeks. Patient walked on the twenty-ninth day post-operative. Discharged November 12, 1927.

Temperature Changes.

	Right (Popliteal vein ligated)	Left
Before operation	89.0	89.5
½ hour after operation	92.0	89.0
1 day after operation	89.5	87.0
4 days after operation	91.0	90.1
7 days after operation	89.2	88.4
10 days after operation	90.2	90.2
12 days after operation	93.0	93.2
14 days after operation deep temp.	93.4	93.8
18 days after operation	89.8	90.0

CASE IV.—M. W., No. 11302, admitted November 28, 1927. The duration of diabetes is unknown. Fourteen years ago the patient had a chronic infection of the right foot for one year. Five years ago she had an ulcer on the right calf that required about ten months to heal. Five weeks before admission the patient cut a corn with a razor and an ulcer developed. The surrounding tissue, became red and tender and the patient experienced severe pain. Frank gangrene developed three weeks before admission.

Physical Examination.—The patient is an emaciated woman of sixty-two years who is quite senile. Right pupil does not react to light and there is a cataract of right lens. Teeth extracted. Heart enlarged with a systolic blow over the precordium. Blood pressure, 130/70. There is sclerosis of all peripheral arteries. The liver edge is palpable. The reflexes are sluggish. Both extremities are pale and cold with impalpable vessels. At the base of the fifth right toe is an excoriation 1 cm. in size and at the base of the right great toe and down the medial side of the foot is an area of gangrene covered with a dry black crust. Hæmoglobin 88 per cent.; white blood-cells 11,680; red blood-cells 5,140,000. Urine: pus cells and albumin. B. coli in culture. Wassermann four plus. Blood sugar 160 mg. per 100 c.c. N. P. N. 36.15 mg. per 100 c.c. Blood culture negative. X-ray shows calcification of vessels of extremity with periostitis of tibiae.

Impression.—Syphilis; diabetes; arteriosclerosis; gangrene right foot; cataract right eye.

Amputation advised and refused. December 13, 1927, ligation of right popliteal vein (very weak pulsation of popliteal artery). *Course:* Diabetes controlled with diet (P. 52 F.118 C.56 Cal.1494). Operative wound healed per primum. Patient would not submit to lumbar puncture, would not coöperate in treatment and left the hospital against advice, December 20, 1927, seven days after operation.

Temperature Changes.

	Right (Popliteal vein ligated)	Left
Before operation	89.6	90.0
10.10 A.M. 12/13/27—Ligation of right popliteal vein		
10.25	87.0	86.0
10.29	87.2	86.2
10.34	87.6	86.0
10.42	88.2	86.0
10.50	87.8	85.6

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Temperature Changes. (Continued)

	Right (Popliteal vein ligated)	Left
10.56	87.8	85.6
11.02	86.9	84.8
11.10	87.0	84.8
11.15	86.9	84.2
11.23	86.9	84.2

Skin Temperature.

30 min. after operation	90.1	90.1
1 hour after operation	90.2	89.2
2 days after operation	91.2	88.0
4 days after operation	92.1	89.4
6 days after operation	91.9	90.1

CASE V[‡].—S. D., Rochester General Hospital No. 43441, male, Jew, thirty-two years of age, admitted January 19, 1928. About one month before admission the patient noticed a redness and swelling of the left great toe with extreme pain in the foot and calf. This was considered an infected ingrown toe nail. He was first seen in the out-patient department of this hospital January 6, where a tentative diagnosis of thrombo-angiitis obliterans was made. At this time the left foot was swollen, reddish-blue in color and cold. There has been excruciating rest pain requiring narcotics. A history of claudication could not be elicited. The patient speaks English poorly and his observation is faulty so that the details of the history probably are inaccurate. There has been numbness of the fingers of the right hand for two weeks.

Physical Examination.—The patient is a well developed male of thirty-two years in severe pain. The teeth are carious, the spleen is palpable and the blood pressure 148/90. *Extremities.*—There has been a partial amputation of the right great toe. The right hand is colder than the left. The left foot is swollen, red at the ankle and becomes purplish-red over the distal portion. There is gangrene of the great toe covered with a hard, dry, black crust with demarcation at the metatarsal phalangeal joint. Red blood-cells 4,600,000; white blood-cells 10,900. Urine: albumin plus; sugar 0; N. P. N. 35.5; blood sugar 80 mg. per 100 c.c. Blood chlorides 520 mg. per 100 c.c. Wassermann negative. X-ray shows no evidence of sclerosis of vessels.

Impression.—Thrombo-angiitis obliterans. (Pulsation of popliteal artery not felt.) Amputation refused. Ligation of left popliteal vein, February 3, 1928. Pulsation was not made out in the popliteal artery at operation.

Course.—Pain was very little relieved, the limb felt cold to the patient and the gangrene steadily progressed. Amputation was indicated and advised but was refused. Discharged February 16, 1928.

Temperature Changes.

	Right	Left (Popliteal vein ligated)
Before	90	90
Operation	88.6	87
2 days after operation	92	90
6 days after operation	91.6	91.8
10 days after operation	92	92.6

CASE VI.—No. 12177, male, fifty-five years, admitted January 1, 1928. Patient has noticed cramps in muscles of legs for four years. In August, 1927, began to have shooting pain in right foot, after walking, accompanied by claudication in leg. These symptoms subsided with rest but appeared more and more frequently. The right foot became red and swollen and four days before admission began to pain even at rest. Patient was told by outside physician that he had diabetes.

[‡] This case is reported through the courtesy of Dr. Howard Prince.

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Physical Examination.—Shows a large, ruddy, middle-aged man in some discomfort. The vessels of the retina are small and tortuous, the teeth are carious, the tonsils are enlarged, the chest is emphysematous, there is a soft systolic murmur at the apex which is not transmitted, all peripheral arteries are tortuous and the blood pressure is 130/80. The right leg is 2.6° F. colder than the left, the popliteal artery is palpable, the posterior tibial is impalpable as is the dorsalis pedis artery. The skin of the right foot is dull in lustre and dusky red in color. There is a black crusted area of gangrene which is 1.7 x 2 cm. in size, at the base of the fourth toe.

Urine.—Sugar two plus; hæmoglobin, 106 per cent.; red blood-cells, 5,400,000; white blood-cells 8,950; blood sugar 122 mg. per 100 c.c.; N. P. N. 36.6 mg. per 100; Was-

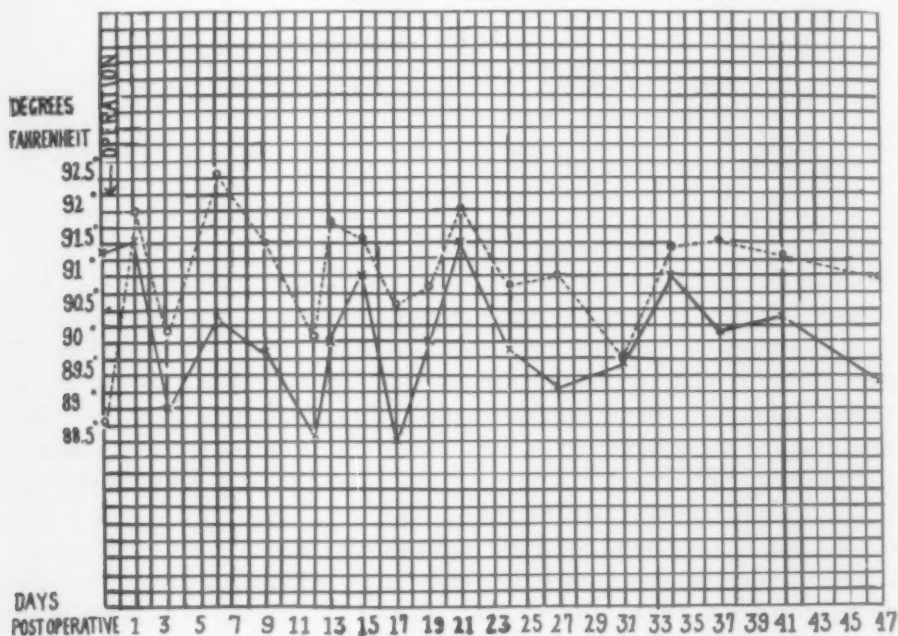


FIG. 3.—Graphic record of the surface temperature changes, registered in degrees Fahrenheit, over a period of forty-seven days, in Case VI. The dotted line is the operated side, the solid line the control.

sermann negative. X-ray shows calcification of the vessels of the right leg through their extent.

Impression.—Diabetes mellitus. Generalized arteriosclerosis. Gangrene right foot.

Operation.—January 19, ligation right popliteal vein (strong pulsation of popliteal artery).

Course.—Immediately after operation, patient lost all pain and tenderness. There was slight œdema of ankle but the skin became pink and toe nails began to grow. There has never been a return of pain. The gangrene area sloughed down to tendon and began to granulate on February 16, 1928. The temperature change is shown in Fig. 3.

CASE V.—J. B., No. 12672, male, sixty-eight years, admitted February 1, 1928. The patient had an infection of the left great toe four years ago and was told he had diabetes. Seven weeks before admission claudication developed in the left leg and two weeks before admission rest pain appeared. Patient has had a chronic cough with dyspnoea and œdema of ankles for fifteen years.

Physical Examination.—The general examination reveals pyorrhœa, emphysema, slight cardiac enlargement, generalized arteriosclerosis and a complete right inguinal hernia. Blood pressure 155/90. *Extremities.*—The right leg is not remarkable. On the left the distal half of the second toe is gangrenous with specks of gangrene on the tips

of the third and fourth toes which after three days progressed to gangrene of the distal portion of the toes. The dorsum of the foot is reddish-purple with scales of epidermis lifted from it. The dorsalis pedis and posterior tibial arteries are not palpable. X-ray shows calcification of the vessels. Urine: Albumin two plus; red blood-cells 5,010,000; white blood-cells 15,000; hæmoglobin 95 per cent.; blood sugar 148 mg. per 100 c.c.; Wassermann negative. February 4, 1928, ligation of left popliteal vein (no pulsation in popliteal artery).

Course.—The gangrene, which had been rapidly progressive since admission was checked for a few days, then it continued to extend and the leg was amputated. February 13, 1928.

Temperature Changes.

	Left (popliteal vein ligated)	Right
2/1/28 before operation	82.0	83.0
2/4/28 before operation	87.0	90.3
30 min. after operation	87.6	89.6
1 hr. after operation	86.6	87.6
1 day after operation	89.0	91.0
2 days after operation	91.0	90.6
4 days after operation	91.4	91.2
6 days after operation	90.0	91.1

DISCUSSION

Observation of the cases presented has shown that in the presence of arterial disease with circulatory deficiency of an extremity, ligation of the popliteal vein results in an increased temperature of the part. The cause and significance of this phenomena is not clear. It is certain that tissue temperature is intimately connected with the circulation, and it is possible that the increased temperature of the extremity having its deep vein ligated results from a better circulation to the part. But this cannot be accurately determined for there is no absolute criterion of circulatory efficiency in a limb. One may gain an impression by the clinical observation of the relation to pain, the effect on œdema, the change in color, the growth of the nails and the effect on fatigue and this impression may be substantiated by the change in the temperature of the part, the absorption of intradermal saline, the return of circulation after blanching, the oscillometer reading, the capillaries of the nail bed and the oxygen carrying capacity of the returning blood. In the cases studied, it appeared that the change in the temperature of the limb correlated closely with the other signs of functional ability of the circulation. It is to be noted that the finding of an increased temperature of the part following vein ligation is at variance with the experimental results of Brooks,¹ who observed an immediate fall in temperature at the time of occluding the vein in a limb having its main artery obstructed. Perhaps the difference lies in the condition of the arteries for in Brooks' experiments the artery was completely obstructed by ligation while in the cases observed the artery was, usually, only partially occluded by the disease.

It has been shown that the arteries and the superficial veins are equipped with a regulating nervous mechanism, and it may be that manipulation of the popliteal vein results in a derangement of the vasomotor mechanism of the

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vessels. It is of interest in this regard to note that Leriche⁶ and his pupils have demonstrated an increased temperature of the limb following periarterial sympathectomy.

It is possible that occlusion of the deep vein shunts the blood through the superficial vessels and this increased vascularization of the periphery causes an increased skin temperature. It has been observed that the superficial veins in these cases become enlarged. But the increased temperature of the muscles indicates that the effect is not only on the surface but also in the deeper structures.

Finally, the study of subsequent cases may reveal other factors involved which have not been adequately considered.

It is believed significant that in Cases V and VII where there was only slight transient elevation of temperature no clinical improvement resulted. While on the other hand, in the remaining cases, the more marked and better sustained increase in temperature correlated with the clinical evidence of improved peripheral circulation.

SUMMARY

Ligation of the popliteal vein in cases of thrombo-angiitis obliterans and arteriosclerotic gangrene results in an elevation of temperature of the extremity.

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PRIMARY BILATERAL TUMORS OF THE TESTICLE

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FROM THE CLEVELAND CLINIC

PRIMARY bilateral tumors of the testicle occur so rarely that it seems advisable to report each case that is seen in order that the true incidence may be known. This seems especially important in view of the fact that Vidal¹ formerly stated that tumors of the testicle were never malignant when both organs were involved simultaneously. The findings in the case which is here reported offer proof which directly contradicts this statement.

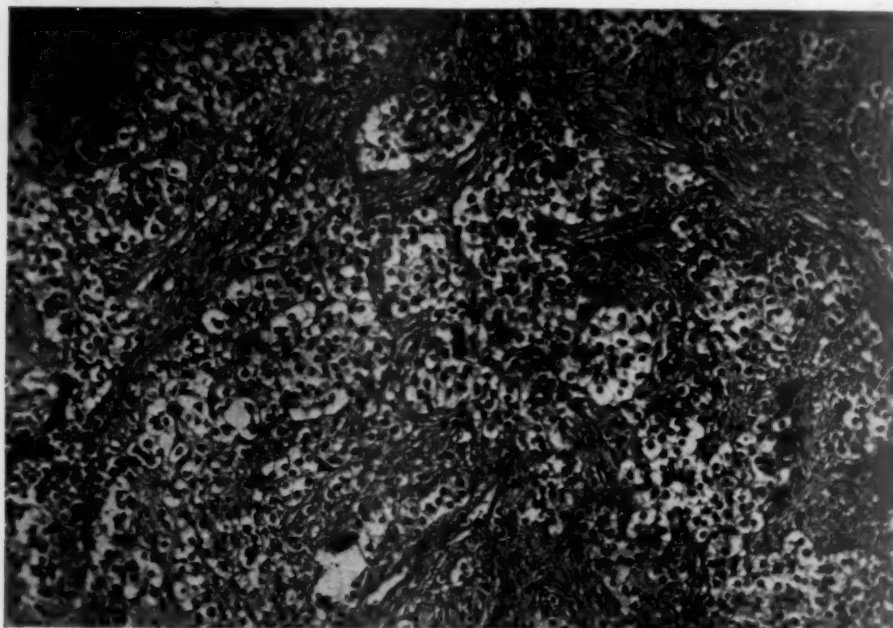


FIG. 1A.—Embryoma of right testicle. Photomicrograph of section. (x 160.)

Kocher,² in reviewing the literature in 1887, found that Curling³ had mentioned six cases of bilateral medullary carcinoma of the testicle, and he found the following cases reported as cases of bilateral sarcoma: Wilson, one; Denonvilliers, one (case of Gosselin); Demarquay, one; Adelmann, one case in a child (Trélat); Curling, one; Klebs, one; Monod, four; Horner, one; Letulle, one; Kraske, one. To these he added two cases of his own, making a total of fifteen.

The question arises in some of Kocher's cases whether the opposite testicle was not involved secondarily. He states that in the majority of the cases a

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pronounced growth of the second testicle was not markedly noticeable until after the first operation, but usually even at the time of the first operation the second testicle was no longer in a normal condition. The second testicle was operated on at intervals of three, four, six and ten months after the first one had been removed.

Other cases of bilateral tumor of the testicle which have been reported are

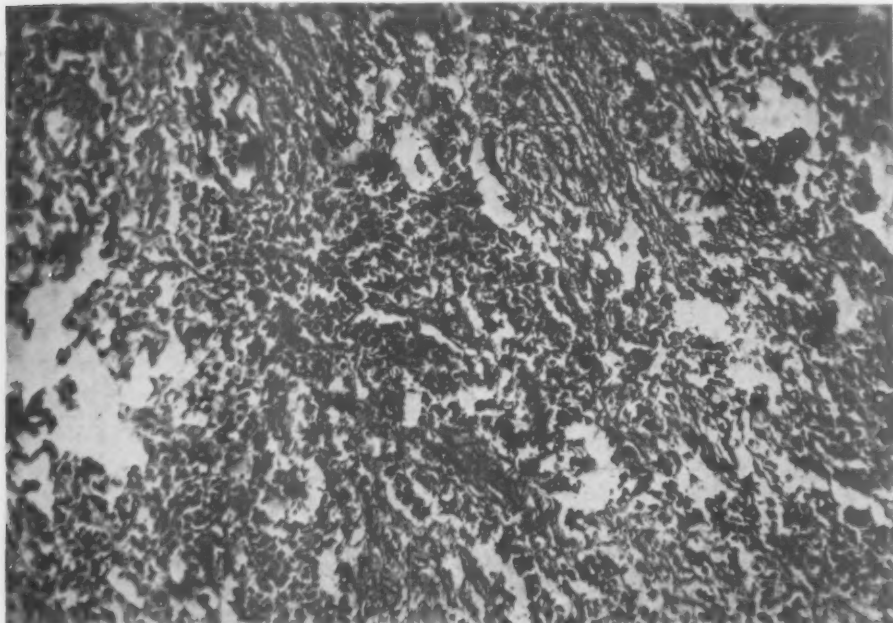


FIG. 2A.—Embryoma of left testicle. Photomicrograph of section. (x 150.)

those of Bidard⁴ (1853), Delaunay⁵ (1860), Sibley and Hulke⁶ (1866), Bowen⁷ (1897), Councilmann and Lovett⁸ (1897), Smith⁹ (1914), Butt and Arkin¹⁰ (1914), Oraison¹¹ (1918), Kaiser¹² (1920), Tanner¹³ (1923).

Klebs,¹⁴ in his "Handbuch der pathologischen Anatomie," states that both testicles are frequently involved, but he is apparently the only author who makes this assertion. In his review of sixty-four cases of cancer of the testis published in 1915, Coley¹⁵ found only one bilateral case, one which had been operated upon by Wyeth¹⁶ in 1905. In this case one testis was retained in the inguinal canal. Bulkley's¹⁷ series of fifty-nine cases of tumor of the testicle retained within the abdominal cavity included only two cases in which there was a bilateral involvement, one the case of Wyeth's which has already been mentioned, the other a case reported by Sabella¹⁸ in 1910.

In recent years but few cases have been reported. Occasionally cases are mentioned in which the opposite testicle has become involved six or seven months after operation or after enlargement of the opposite had been noted, but they cannot be classified as cases of primary bilateral involvement.

Etiology.—The etiology, the influence of trauma and of persistent irrita-

tion and the relationship of maldescent of the testes to the formation of tumor have been discussed in a previous paper,¹⁹ in which twenty-three cases of unilateral malignant tumor of the testis were reported. In the majority of these cases enlargement had been discernible before the trauma occurred. In most instances, also, the testicles had descended normally and the enlargement had occurred in later years.

Pathology.—Because of confusion existing in the classification of testicu-

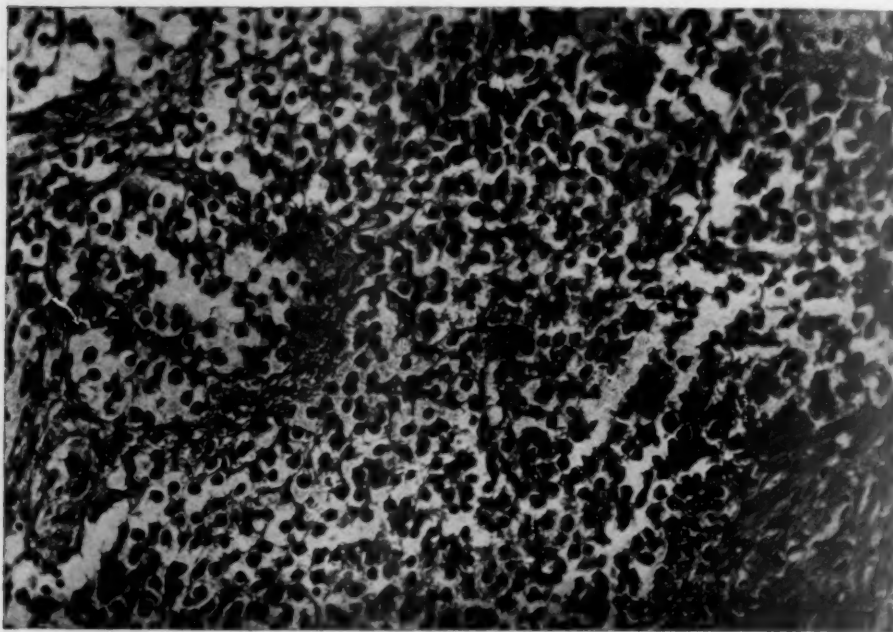


FIG. 2A.—Embryoma of right testicle. Photomicrograph of section. (x 250.)

lar tumors, the pathological reports which are given in case reports in the literature often do not agree. Kocher states that variations occur in round-cell sarcomata, the tissues presenting the appearance of small-cell, large-cell and even of giant-cell sarcoma. He states that a number of small round-cell sarcomata fall into the group classified by the French as lymphadenoma and by Kocher himself as lymphoid sarcoma, the microscopic picture revealing the presence of a fibrinous intracellular substance situated between the small round cells. These tumors are very malignant. From the descriptions, however, I believe that many of the tumors fall into the group of embryomata, in which we see large, irregular, deeply staining cells held in a moderately dense and rather loosely arranged fibrous connective tissue.

Kocher also points out the fact that some of the cases which had been reported as cases of sarcoma—notably those of Wilson, Denonvilliers, Demarquay and Adelman might be considered—cases of carcinoma, stating that the same question might be raised in one of his own cases.

PRIMARY BILATERAL TUMORS OF THE TESTICLE

In some of the older cases, as for instance, those of Gosselin²⁰ and Bowen⁷ no pathological report is available.

Age Incidence.—The majority of the cases of bilateral tumor of the testicle seem to occur in adult life, no case having been found in a child.

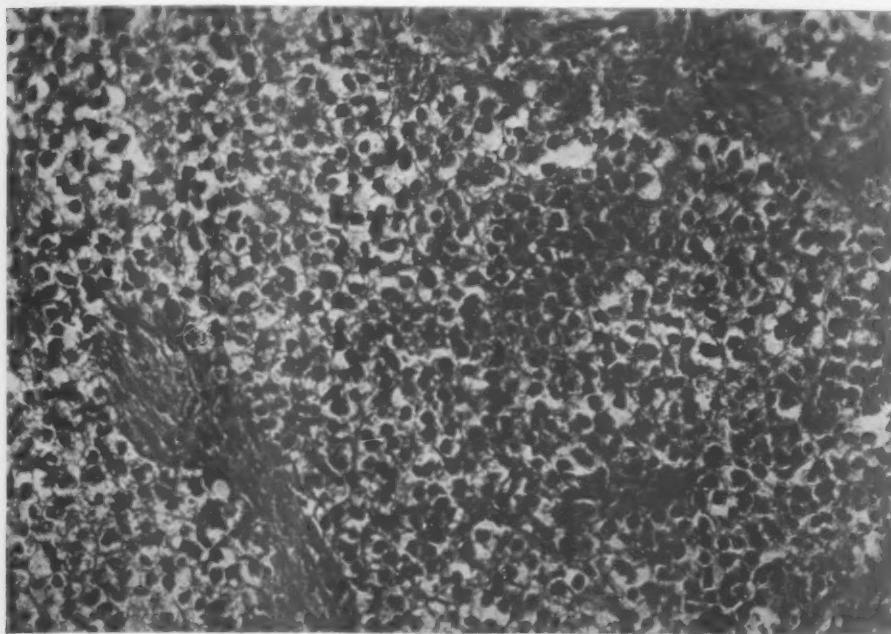


FIG. 2B.—Embryoma of left testicle. Photomicrograph of section. (x 250.)

The following list gives the ages of the patients in the cases in which this has been noted:

Author	No. of cases	Age of patient
Kraske	1	42
Kaiser	1	54
Gosselin	1	32
Sibley	1	57
Tanner	1	45
Bidard	1	27
Delaunay	1	30
Oraison	1	54
Wyeth	1	33
Butt and Arkin.....	1	48
Bunts (case here reported).....		54

Diagnosis.—The signs and symptoms upon which a diagnosis is based are the same as in the case of unilateral tumors, and here, too, the presence of a coexisting hydrocele may offer difficulty in establishing a definite diagnosis. It may not be suspected that an enlargement of both testicles is present until operation is being performed. In cases in which the enlargement of the opposite testicle ensues months after the primary operation, the diagnosis is less difficult.

Treatment.—The treatment is the same as that for unilateral tumors. We recommend orchidectomy and deep radiation of the inguinal and lumbar glands. Coley's serum is also recommended for this condition. However, in all cases of malignant tumor of the testis there is grave danger of early metastasis and the end-results of all forms of treatment have been unsatisfactory.

CASE REPORT.—The patient, a man fifty-four years of age, entered the hospital in the service of Dr. F. E. Bunts, complaining of swelling of the left testicle. The patient's past history and the family history were unimportant. The swelling had not been associated with pain until one year before, at which time the testicle had been subjected to trauma. The pain recurred in paroxysmal attacks and the swelling progressed steadily. There was no pain in the right testicle.

Physical examination gave essentially negative results except for the findings in the scrotum. The left testicle was enlarged, firm, and in one area it was stony hard. The tumor mass was approximately the size of an orange. A cystic condition was also present in the right scrotum and this was thought to contain a large hydrocele, as light was transmitted through it. No hydrocele was present on the left side.

The left testicle was removed and it was found that the right testicle was also enlarged. As permission had not been granted for the removal of both testicles, the right one was not removed until eight days later.

The patient returned eight months after the operations and stated that shortly after he left the hospital pain developed in the lumbosacral region. It was then a shooting pain which radiated down the legs. Incontinence of feces and of urine had also developed and a paralysis of both legs below the knee. Röntgenograms made at this time showed no evidence of metastasis; however the patient is reported to have died of carcinoma of the transverse colon three months after our examination.

Pathological Report.—Left testicle: A testicle and epididymis which together are the size of an orange, showing a finely nodular surface, and on section presenting a rubbery yellowish-white cut surface fairly uniform in appearance.

Microscopic Description.—Section through the testicle and epididymis shows a very cellular growth characterized by large, irregular, deeply chromatic cells, with pyknotic and mitotic nuclei held in a moderately dense, rather loosely arranged fibrous stroma of connective tissue, the cells being arranged in some instances in large masses, in other instances in somewhat alveolarlike formations.

Histological Diagnosis.—Embryoma of testicle.

The pathological report of the opposite testicle was the same, the pathologist stating that the tumors were identical.

SUMMARY

In reviewing the cases of malignant tumor of the testes reported in the literature, we find that a primarily bilateral involvement has been reported in only a few cases.

A case of primary bilateral embryoma is reported, in order that the incidence of these bilateral tumors may be known and emphasis laid on the importance of a careful examination of the opposite testicle in all cases of unilateral tumor.

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PRIMARY BILATERAL TUMORS OF THE TESTICLE

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PHAGEDÆNIC ULCERATION OF THE SKIN

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PROGRESSIVE gangrenous sloughing ulceration of the skin is of rare occurrence. Brewer and Meleney report two cases which occurred within their own experience, and cited four other cases, two of which were personal communications, and the other

two were reported in the literature. The majority of the cases, as well as the case here reported, followed operation for acute perforative appendicitis.

The condition is characterized by its chronicity; its insidious progressiveness, being particularly rebellious to all treatment except wide excision; and its extreme sensitiveness. The constitutional symptoms are those of a chronic infection—loss of weight, haggardness, slight secondary anemia, low grade irregular fever, and leukocytosis. This case well illustrates not only the physical incapacity which occurs but also the economic loss which it entails. This man



FIG. 1.—Photograph of healed portion of the lesion on admittance.

had to dispose of his business, and was under rather constant hospitalization and medical attendance for a year.

CASE HISTORY.—J. P.; Case No. 54433; came under observation on July 7, 1927. He was thirty-nine years of age; born in Poland and came to the United States in 1909.

His family and past history were entirely without bearing on his present illness.

He stated that the present illness dated back to November 23, 1926. The evening of that day he was quite suddenly seized with abdominal cramps. The following evening he was operated upon for an acute appendicitis. He was told that he had a "bad"

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appendix. The wound was closed without drainage. For the first few days thereafter the patient was very sick; had a high fever and was delirious. About the fifth day the wound was dressed, and the patient noticed what looked to him like a boil at the upper and outer margin of the wound. There was a thin pussy discharge from the lesion. This progressed gradually despite all attempts at drainage and treatment. He remained in the hospital for ten weeks. At this time the lesion had progressed upward beneath the right arm and toward the axilla. The lesion healed in its wake. Its advancing margin was a nasty sloughing ulcer and was very painful. He went every other day to his physician for a dressing and treatment. During this time he stated that everything was tried to arrest the ulcer, including X-ray and Alpine light treatment.

The man on examination showed the evidences of a chronic infection. His musculature was generally flabby from loss of weight and inactivity. He looked haggard. His hæmoglobin was 89 per cent. (Dare). His leukocyte count was 17,700. The urine was negative. The blood sugar was 0.17.

On viewing him from in front there was a healed operative scar in the right lower quadrant of the abdomen. Extending from the upper angle of this, as the photograph (Fig. 1) shows, was a ser-



FIG. 2.—Showing the ulceration of the back on admission. Note the dead undermined margins and the purulent exudate.

piginous scar, extending in ramifications up toward the right axilla. On the back, below the right scapula, this healed lesion was continuous with a large ulceration of the skin, measuring approximately 9 x 6 inches. (Fig. 2.) It extended from the crest of the ileum below to the scapula above, and from the posterior axillary line to the spine. The border of the advancing margin was formed by a broad zone in which the œdematous, inflamed, cyanotic area gradually faded into normal skin. The advancing edge of the ulcer was raised, undermined, and exuded a thick purulent secretion. In places the dead, sloughing skin, which exuded pus, was still attached. The base of the ulcer, especially near the healed margin, was formed by a red, granulating surface, over which new epithelium was extending.

At consultation the suggested diagnoses were lues, mycotic skin infection and tuberculosis. Repeated blood Wassermanns were negative. Repeated examinations of the wound were negative for any fungus infection.

Therapy included a course of neo-salvarsan intravenously; large doses of saturated solution of potassium iodide by mouth; copper sulphate in one grain doses by mouth and in a dilute solution to the wound; Dakin's solution and mercurochrome were also tried locally. In spite of everything the lesion progressed. It gave no evidence of abatement



FIG. 4.—Photograph made on October 13, 1927, seven weeks after excision of the ulcer. Note healing is practically complete.

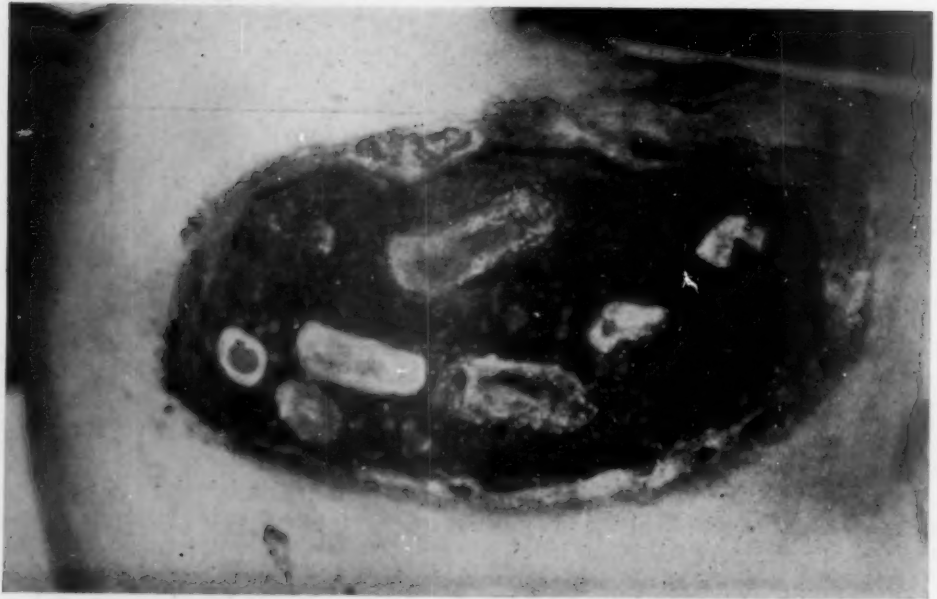


FIG. 3.—Photograph after excision of ulcer and skin grafting. Note growth of epithelium from margin of grafts and ulcer.

PHAGEDÆNIC ULCERATION OF THE SKIN

under treatment. It was extremely sensitive. The man was irritable. He looked haggard; his appetite was poor; and he did not rest well.

It was finally agreed to widely excise this large ulcer, and this was done on July 21, 1927, under gas ether anaesthesia. The line of incision was placed well beyond the lesion, traversing normal skin, and included all the subcutaneous tissue down to the muscles of the back. The base of the ulcer was cauterized.

Following recovery from the immediate shock of the operation and after the immediate pain had subsided, there was a marked change in the man. He lost the evidence of chronic infection. He looked happy; his appetite improved; and he was able to rest very well. Within ten days the base of the ulcer was covered by a good, clean, granulating surface. Skin grafting was done on three occasions—on August 10, August 15, and August 23—and very successfully, each graft taking and growing very rapidly. (Fig. 3.) During his entire convalescence he was particularly happy and rapidly gained in weight and strength. At the time he left the hospital, on September 9, this large defect was rapidly closing by epithelium which was extending out from the margin of the ulcer and from the skin grafts.

On October 13, 1927, the final photograph (Fig. 4) was taken, which showed the lesion to be practically covered with epithelium.

Paraffin section of the specimen made at the time of the excision of the ulcer and stained by Gram's method showed staphylococci, Gram-positive diplococci and short chains of streptococci.

This case report seems to bear out Brewer's and Meleney's idea that progressive gangrene of the skin is due to the symbiotic action of two or more types of organisms, and in this case, as in the cases which they report, the streptococcus and the staphylococcus seemed to be the inciting organisms.

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FRACTURE AND DISLOCATION OF THE STERNUM *

REPORT OF THREE CASES

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ALL statistics bear out the statement that fracture of the sternum is exceedingly rare. Gurlt,¹ in 1864, cited a series of 22,616 fractures of all types treated at the London Hospital during a period of twenty years. Among them were only twenty-two cases of uncomplicated fracture of the sternum, or 0.098 per cent. Bruns² gives the incidence as seventeen cases in a series of 8,560 fractures (0.2 per cent.); Chudowsky,³ as six in 2,366 (0.3 per cent.); Plagemann,⁴ five in 1,393 (0.36 per cent.). Speed⁵ reported twelve fractures of the sternum in a series of 11,302 fractures treated at the Cook County Hospital during a period of eight years.

The most carefully studied series of cases yet reported was Gurlt's, which was based on a complete survey of the literature up to 1864. Gurlt was able to obtain data on a total of 105 cases. My study of five exceedingly large fracture services revealed sixty-two cases in a total of 46,237 fractures or 0.075 per cent. At Locust Mountain State Hospital during the first year of its opening for patients three cases were detected in a series of 157 fractures, or 1.91 per cent.

Fractures of the sternum are rare because the mobility and elasticity of the thorax protect this bone. Indirect violence rarely produces it, because the ribs are much more likely to break first. Direct injury is the most common cause. However, cases of fracture have been reported not only from indirect violence but also from muscular action.

In ninety-eight cases analyzed by Gurlt with regard to etiology, eight were produced by muscular action; forty-two by falling down from a height; three by powerful bending head foremost; three by violent bending backward; twelve by a blow, thrust, or step on the chest; twenty-two by compression of the chest from being run over, buried, or by the fall of a heavy weight; and eighty by falling with the breast against a solid body.

The usual causes of fracture of the sternum have been given as direct blows on the chest, such as occur in car-bumper accidents, compression of the chest, hyperflexion of the spine associated with fractures of the vertebral column, run-over accidents and falls, and the falling of heavy weights on the

* Thesis submitted to the Faculty of the Graduate School of Medicine of the University of Pennsylvania in partial fulfillment of the requirements for the degree of Master of Medical Science (M.Sc.(Med.)) for graduate work in Surgery.

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chest. As an example of fracture by muscular action, there have been cases occurring in the course of labor. According to Stimson,⁶ four such cases have been reported. Three similar cases were caused by the effort involved in lifting a heavy weight.

Some of the unusual cases of fracture of the sternum deserve special mention. Maligne⁷ related the case of a mountebank who fractured his sternum while leaning backward to lift a weight. Gutzeit⁸ cited a case of transverse fracture of the sternum at the junction of the manubrium and gladiolus produced by muscular action. The accident occurred while the patient was chinning the bar in the gymnasium and swinging for support. Kazda⁹ reported three similar cases produced by injuries incidental to gymnastic exercises.

Brunn¹⁰ reported three cases of transverse fracture at the junction of the manubrium and gladiolus produced by indirect violence. In each case the cause was the same; namely, the fall of a heavy weight on the back of the neck and the upper portion of the vertebral column, while the body was slightly bent. Servier,¹¹ in 1889, was able to collect only twenty cases of indirect or contrecoup fracture of the sternum. Tarnowsky,¹² in 1905, added seven new cases collected since 1889, all of them except one being due to muscular action.

Michaux¹³ cited a case of fracture of the gladiolus produced by direct violence. While leading an unruly ox, the patient was attacked by the animal, whose horn fractured the sternum. Knowles¹⁴

reported a case of transverse fracture extending from one-third costal articulation to the other in a Hindoo who was attacked by a wild boar. The patient died later of septic pneumonia.

MacLaurin¹⁵ reported a case of the exceedingly rare condition of fracture-dislocation of the ensiform appendix. The patient was a muscular man and the fracture was produced by the action of his anterior abdominal muscles, while he was trying to save himself from falling forward from a sitting position on a bench. On examination, there was a large hollow at the lower end of the sternum which proved to be the result of a forward projection of the ensiform, which lay so that its lower end was tilted forward. Gurlt's series contains four cases of this type.



FIG. 1.—(Lateral view of chest.) Showing an anterior dislocation of the upper end of the gladiolus at its junction with the manubrium.

With rare exceptions fractures of the sternum, exclusive of those that are produced by gunshot or stab wounds, are simple. A notable exception in the way of a compound fracture was the case reported by Du Verney¹⁶ in 1751. The patient was a quarryman who, while lying at work on his side, was caught under a heavy stone five feet long, which compressed his chest

laterally with such force as to separate the middle from the upper portion of the sternum and force it through the skin. The subject died immediately from rupture of the heart and lungs.

The most common type of fracture is a transverse break at the junction of the manubrium with the gladiolus. In the great majority of cases the displacement is such that the lower fragment lies partially in front of the upper one, sometimes overriding it. In children the injury may take the form of a dislocation between the manubrium and the gladiolus.

Of interest with regard to the most common type of fracture of the sternum is specimen No. 5156 in the Warren Anatomical Museum, a photographic reproduction of which appears in Wilson and Cochrane on "Fractures and Dislocations."



FIG. 2.—(Lateral view.) Showing an oblique fracture of the gladiolus just below the middle. The third piece of the sternum, it is noted, is not attached to the second piece but inasmuch as the space is filled with cartilage this is probably a normal condition. Fracture did not show in A P view.

Fractures of the gladiolus are less common. They are located most frequently between the second and fourth costal cartilages and are usually transverse; there is partial overriding of the lower fragment as in separation of the manubrium from the gladiolus.

Except when other injuries are associated, comminuted fractures of the sternum are rare. Gurlt cited six instances of double fracture and two of triple fracture, all of them associated with other fractures elsewhere.

FRACTURE AND DISLOCATION OF THE STERNUM

Though of rare occurrence, several cases of secondary rupture of the internal mammary vessels were reported during the World War. Bonnet and Barbier¹⁷ saw two such cases. In one, the rupture occurred on the fourth day after injury and was successfully controlled by tamponing under general anaesthesia. In the other case, the accident occurred on the fifth day following a fit of coughing. Fracture of the sternum may be followed by serious complications in the lungs. Wassermann,¹⁸ in 1899, published an exhaustive study showing a high incidence of traumatic pneumonia and active tuberculous infections after such injuries.

According to Wilson and Cochrane,¹⁹ the diagnosis is usually quite obvious. At the seat of the fracture there are local pain and tenderness and later ecchymosis. The deformity, caused by the displacement forward of the lower fragment, may cause a visible and palpable deformity in the form of a ridge near the junction of the second costal cartilages. When the lung is injured, dyspnoea and haemoptysis are likely to be present.

Roberts and Kelly²⁰ state that the attitude of the patient is often characteristic. He takes a sitting position with the shoulders drooped and part of their weight supported by the arms on each side of the bed.

DaCosta²¹ attaches importance to the history of the injury in making the diagnosis. He describes the posture as one with the head and body bent forward; attempts to straighten up cause considerable pain. He believes that crepitus should be elicited by palpation, placing the hand over the injury and asking the patient to take a quick breath.

The prognosis is good in uncomplicated cases but decidedly bad when there are complications. Fifty-four of Gurlt's cases were uncomplicated, with forty-six recoveries and eight deaths. There were forty-four complicated cases with only one recovery.

Repair with the formation of a bony callus takes place in from four to eight weeks. There may be some degree of persistent deformity, depending on the thoroughness with which the fracture is reduced. Occasionally bony



FIG. 3.—(Lateral view of chest.) Showing an oblique fracture of the middle of the gladiolus with slight depression of the upper portion. Fracture did not show in A P view.

union fails to occur. This does not cause any serious disability other than temporary inability to abduct and adduct the arms.

According to Scudder,²² the fracture may sometimes be reduced by placing the patient on his back with the head extended over the end of the table, and then raising the arms above his head and rotating them outward slowly and forcibly. In the meantime, the patient's body is held by an assistant; thus the procedure described above makes traction and counter-traction on the two fragments.

After the fragments have been reduced, an adhesive plaster swathe is placed high up about the shoulder. It is held firmly in this position by straps across the shoulder. The patient must remain in bed for three weeks but may be allowed up occasionally thereafter, being careful, however, to avoid heavy exertion. A Taylor steel back-brace should be worn for two months thereafter as an additional precaution.

Operative treatment, according to Scudder, is frequently justifiable. An incision may be made and the depressed fragments elevated as soon as the shock of the original injury has passed away. In some cases cyanosis and dyspnoea are removed immediately the deformity is corrected.

When displacement is visible and painful and causes crepitus and pain at each inspiration, Speed²³ advises reduction by extending the spine and drawing the shoulders back during deep inspiration. This manipulation elevates the upper fragment so that the lower fragment or its attached ribs may be pressed on until the deformity is overcome. The reduction may be retained by placing a pad between the scapulæ and using a figure-of-eight bandage to hold the shoulders back.

Roberts and Kelly²⁴ state that an open operation is justifiable when reduction cannot be accomplished by manipulation. An incision is made over the seat of the fracture and the depressed fragment is elevated by any suitable instrument. After being replaced, it may be retained in position by a plate or nail or by direct suture with chromic catgut or silver wire. Although union takes place within eight weeks, it is advisable to have the patient wear for a few months a brace or a gypsum jacket similar to that used for fractures of the spine.

Stimson,²⁵ on the other hand, believes that, unless the displacement is causing dangerous symptoms, the open operation is not justifiable because of its risks. He cites two cases in which attempts at reduction by the open method were failures. In a case of fracture of the upper part of the sternum with depression of the lower fragment, an incision was made with the intention of introducing a hook, but the pleural cavity was opened accidentally and it was necessary to close the wound immediately. In the second case quoted, the upper fragment was raised to the proper level by screwing a sort of gimlet into it and drawing it forward; but unfortunately it sank partly back again and a second attempt to elevate it was frustrated by the tearing out of the screw.

REPORTS OF CASES

CASE I.—A. G., a miner, aged twenty, brought to the hospital in the Reading Coal Company ambulance, following an accidental squeeze between mine cars at Mahanoy City Tunnel Ridge Colliery, November 26, 1926, in shock and severe pain. On admission his temperature was 97.8, his pulse, 114, and respirations, 46; the face was deeply cyanosed as was the neck also, and his expression was anxious.

The physical signs pointed to a fracture or fracture-dislocation of the gladiolus at its junction with the manubrium; there were no fractures of the ribs. There was extreme tenderness over the spine and a beginning hæmatoma was in evidence. Because of the

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corpulence of the patient a definite diagnosis of fracture of the spine clinically could not be made, but with this suspicion in mind the patient was later X-rayed. There were no neurologic symptoms. The patient was treated for his shock in the Accident Receiving Ward before being sent to the ward.

X-ray examination No. 927 revealed the following: There is no definite fracture of any of the ribs. There is no definite evidence of fracture in the region of the hips. Examination of the lumbar spine shows a compression type of fracture of the second lumbar vertebra, the under surface of the first and the upper surface of the third sharing somewhat in this compression. The spinous process of the first and second on the right side are fractured. There is no lateral displacement in the fracture of these vertebrae but the second is displaced backward on the third possibly a quarter of an inch. Examination of the sternum shows an anterior dislocation of the upper end of the gladiolus at its junction with the manubrium.

After all symptoms of shock abated the patient was placed on a Bradford frame on which he was fairly comfortable. The symptoms of his *traumatic asphyxia* did not disappear until after two weeks. The upper end of the gladiolus was pushed down by digital pressure and held in place with an adhesive swathe. The patient had a plaster jacket applied while in a Sayre suspension on December 30, 1926, which was removed and replaced by a celluloid jacket which laced up the front. This was made from the model of the plaster of Paris. He was discharged from the hospital February 7, 1927, as "well". He stated to me on leaving that he felt excellent.

Follow-up report from his referring physician, Doctor Seligman of Mahanoy City under date of May 7, 1927, stated that his condition was good and that he was improving; he judged his functional result to be 75 per cent. A later follow-up report from the doctor under date of August 6, 1927, reported his condition as good and his functional result 90 per cent. He has resumed light work and the patient informed me in September that he was playing foot-ball.

CASE II.—A. G., a miner, aged forty, brought to the hospital in the Reading Coal Company ambulance, March 14, 1927, with the history that that morning he was squeezed between a car and a fall of coal an hour before his admission, at St. Nicholas Colliery. At the time of his admission his temperature was 96.4, his pulse, 64, and respiration, 22; there was no cyanosis but he complained of intense pain over the entire front of the chest with extreme tenderness over the second portion of the sternum with slight deformity. Beyond the above findings and a slight subconjunctival hemorrhage of the left eye, the examination was otherwise negative. Admission diagnosis of fracture of the gladiolus was made and X-ray examination made immediately revealed the following:

Examination of X-ray plates No. 1205 reveal an oblique fracture of the second piece of the sternum just below the middle. There is considerable depression of the upper fragment and some overlapping. The third piece is not attached to the second piece but this probably is a normal condition, the space being filled with cartilage.

After the patient was admitted to the Men's Surgical Ward, the overlapping was corrected easily by digital pressure and an adhesive swathe applied. He was bedfast for four weeks and was discharged as "improved" on April 29, 1927. He returned to our Surgical Dispensary for several weeks after his discharge.

X-ray examination No. 1320, under date of May 9, 1927, revealed a fracture of the lower end of the middle piece of the sternum, the position satisfactory, and callus present. No follow-up reports were returned by this patient and as he had no referring physician, having been rushed to the hospital immediately following his accident, his condition at this time is not known except that his employer states that he is at his usual occupation of coal mining.

CASE III.—J. G., a miner, aged sixty-three, was brought to the hospital in the Locust Mountain Coal Company Colliery ambulance, March 21, 1927, at 3:25 P.M., a few minutes after an accident at Weston Colliery where he was caught between falling timber and a breast of coal. On admission his temperature was 97.8, pulse, 70, and respiration, 26.

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He complained of extreme pain in the chest, shoulder, and scalp. Examination in the Accident Receiving Ward revealed an extensive coal dirt contaminated laceration of the scalp, a bilateral inguinal hernia, extensive varicose veins, and a probable fracture of the sternum; a scar on the left leg from osteomyelitis of many years ago. Because of the extreme weakness and pain the patient was not disturbed but treated for his shock to which he responded nicely. X-ray examination that night, No. 1244, revealed an oblique fracture of the middle of the second piece of the sternum; not much displacement, and the position satisfactory. There was no evidence of fracture of the skull.

This patient was later removed to the Men's Surgical Ward and an adhesive swathe was placed over the area without any manipulation. The patient felt very comfortable after this and the following day his laceration of the scalp was repaired under local anaesthesia. He was bedfast for three weeks and was discharged from the hospital as "improved", April 22, 1927. He made several visits to our Dispensary and is enjoying the comforts of his home and the community. He does not intend to return to mining but has retired on the advice of his large family, having had forty years of mining. His sternum is such that he could resume his former occupation. These three cases left the hospital alive and in good condition.

CONCLUSIONS

1. Statistics show that fracture of the sternum is exceedingly rare.
2. Diagnosis is best made by X-ray in the lateral position.
3. In proportion to other fractures, fracture of the sternum is more frequently seen in mining communities and must always be outruled in the diagnosis where injuries occur about the chest.
4. The treatment is simple, satisfactory, and affords relief from a very painful condition.

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TREATMENT OF FRACTURES INVOLVING THE ANKLE-JOINT

WITH SPECIAL REFERENCE TO THE USE OF THE PILLOW SPLINT
AND EARLY WEIGHT-BEARING

By FRASER B. GURD, M.D.

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SINCE fracture of the tibia or the fibula, as the result of forced internal rotation of the foot, is extremely rare, nay, probably does not occur at all unless in the individual case the movement of internal rotation gives way to tibial flexion, there remain four separate mechanisms as the result of which fracture of the ankle-joint may occur. We thus have fractures of either tibia or fibula, or both, as the result of:

1. Fracture by external rotation of the foot.
2. Fracture by abduction (fibular flexion of the foot).
3. Fracture by adduction (tibial flexion of the foot).
4. Fracture by upward thrust.

Those fractures due to upward thrust require reclassification depending upon whether the off-centre direction of trauma is forward, backward or to either side. Fractures of this group have a great tendency to be atypical and require consideration individually rather than as a class.

Although in all doubtful cases the fact of fracture must depend upon radiologic examination, the likelihood of fracture is usually clearly indicated. More important, however, than simple diagnosis of fracture is the necessity for an accurate diagnosis of the mechanism, whereby the fracture was produced. As a rule such a diagnosis can be made by an examination of the limb coupled with the patient's history as to the nature of the trauma. In any event the case, in which an exact diagnosis is not possible from a radiologic examination, must be extremely rare.

We are of the opinion that we are in a position to make two contributions from the Montreal General Hospital which make for better results in the treatment of fractures involving the ankle-joint. I refer to the employment of the pillow splint as a primary fixation apparatus and to the early ambulatory treatment of the case with weight-bearing.

The pillow splint has been employed in the Montreal General Hospital for the past twenty-five years, but to the author's knowledge its description has never been published.

The importance of accurate replacement of bone fragments, together with the relief of strain upon the injured ligaments, is appreciated by all surgeons. It is furthermore, I believe, now accepted that early—or if possible immediate—reduction is of paramount importance.

In a fairly large proportion of cases of fractures about the ankle-joint, the

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parts slip back into the normal position when the traumatizing force is arrested. In such cases it is evident that manipulation for purposes of reduction is not necessary, fixation in an over-corrected position of the foot alone is required. In those cases in which deformity is present, replacement of the bones and bone fragments in their normal position is accomplished by means of manipulation under an anæsthetic.

In our clinic, following reduction, the limb is placed in a pillow splint. For this purpose a moderately large, deep feather pillow is required, covered with a pillow slip made of sound, strong material. The leg is placed upon the centre of the pillow, with the latter projecting about six inches beyond the heel. The pillow is made to encircle the leg commencing about, or better above, the knee and firmly secured under tension by means of safety pins passed in the long axis of the limb. Working from above downward toward the ankle-joint, safety pins are placed in this way at short intervals. In this manner lateral and circular compression is exerted; this is of value in limiting œdematous swelling and of forcing by gradual pressure, if reduction has been incomplete, displaced bones into position. Particularly is this useful in overcoming diastasis of the fibula from the tibia. (Fig. 1.)

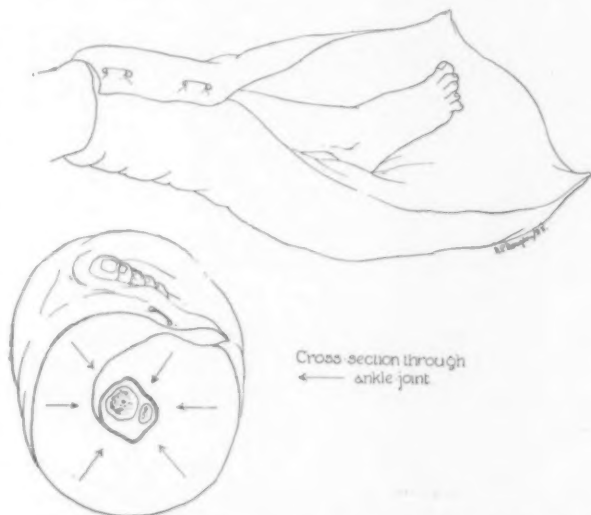


FIG. 1.—Drawing showing position of the foot on the pillow at the commencement of application of splint. This drawing also shows the manner in which diastasis and swelling are overcome by the splint.

swelling and of forcing by gradual pressure, if reduction has been incomplete, displaced bones into position. Particularly is this useful in overcoming diastasis of the fibula from the tibia. (Fig. 1.)

The projecting portion of the pillow below the foot is folded over the sole in such a way that the foot is forced into as marked dorsiflexion as possible, and in such a manner that abduction, or adduction, is induced as required. (Figs. 2 and 3.)

The pillow splint in our hands has for many years proved efficient. It is, moreover, safe in that it is almost inconceivable that strangulation of tissue could be induced by its application, nor, if reasonable care be taken, is there any risk of compounding the severe type of case. It can readily be opened up for observation of the limb, and as a matter of fact must be readjusted several times during the first two or three days following its application.

Too great stress cannot be laid upon the fact that the pillow splint is, as the name suggests, essentially a pillow so placed under tension that it acts as a splint. The pillow itself is not used as padding and the frequent employment of a pillow placed about the limb with two or more longitudinal pieces of

wood fixed by means of strapping or bandaging to the outer surface of the pillow does not constitute a pillow splint. No other method of fixation of the pillow other than safety pins has proved successful, although it is, of course, evident that a special form of clamp similar to a towel clip might be devised to take the place of the safety pins.

The limb is allowed to remain fixed in the pillow splint for a variable number of days, the length of time being dependent upon several factors, more especially the severity of the injury and amount of swelling present.

As a permanent dressing for fractures about the ankle-joint nothing is

so useful as plaster-of-Paris. It has been our custom to employ this material in the form of a cast fashioned with circular bandages. In the more severe type of case the first cast should fix the knee-joint in flexion. As a rule, however, plaster reaching from immediately below the knee to the base of the first three toes and covering the fourth and fifth toes suffices. If swelling has subsided, before the application of plaster, it is recommended that the

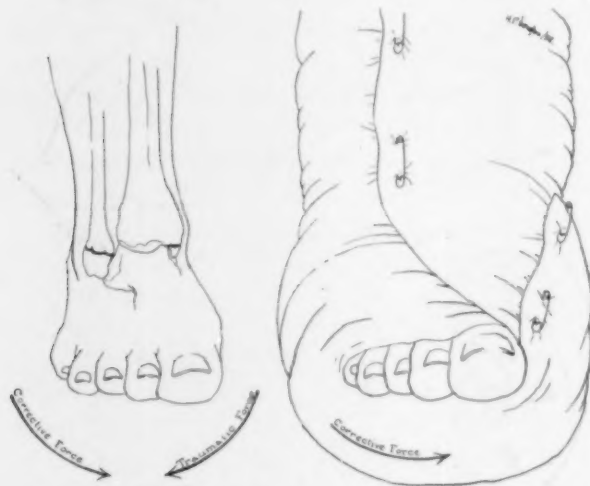


FIG. 2.—Drawing showing manner of employing a corner of the pillow to bring about correction of displacement in fractures due to fibular flexion.

plaster be applied to the limb without the employment of padding.

Following immediate reduction of those cases showing evident deformity, X-ray examination should be made with the limb in the pillow splint. If adequate correction has been obtained, the limb may quite profitably be allowed to remain in the splint for a period of days, until such time as swelling has subsided. Should radiologic examination prove that adequate reduction has not been obtained, further anaesthesia is required and an attempt made to completely overcome the residual deformity.

The first plaster-of-Paris fixation apparatus is allowed to remain in place for a period of about ten days. At the completion of this period the cast is removed, the posterior part preserved to act as a splint, and light massage, diathermy, baking and active movements employed. In the most severe type of case it is advisable to carry out physiotherapy for a period of three to six days at this time.

The limb is then replaced in a circular plaster often reinforced by a posterior moulded piece. No padding is applied, one layer of stockingette only is placed about the limb and the foot is fixed in as dorsiflexed a position as possible. After the plaster has dried, a heel approximately one inch in

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thickness is attached to the bottom of the cast by means of adhesive plaster. This heel is made of saddler's felt. The patient is then urged to commence weight-bearing upon the injured limb, either with or without the help of crutches or stick. In the application of this walking plaster, care must be taken to apply the bandages evenly and snugly to the limb. Particular attention must be paid to moulding the plaster accurately to the malleoli and to the tuberosities of the tibia and lower border of the patella. The body weight is to be borne directly from the heel on the plaster to the expanded upper end of the tibia and lower border of the patella, therefore care must be taken to ensure a perfect fit of the bucket which the upper end of the plaster constitutes. (Fig. 4.)

Patients whose time is valuable have a boot made so that their deformity is less noticeable, and go about their business as soon as this second plaster is applied, that is, about ten days or two weeks after the more severe types of injury. In cases of oblique fracture of the lower end of the fibula due to

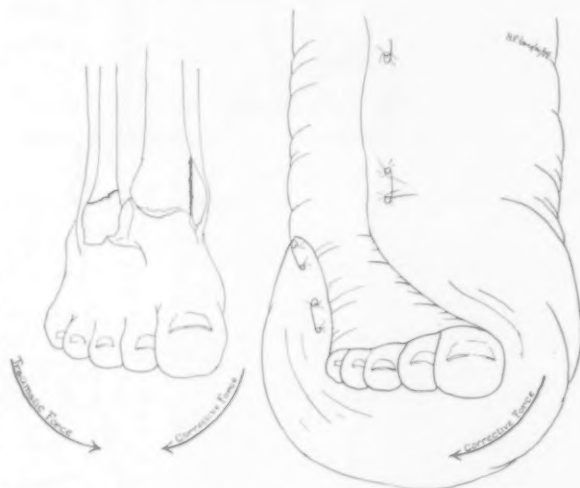


FIG. 3.—Manner of employing pillow in correction of deformity in cases due to tibial flexion.

external rotation, the patient is usually able to walk without crutch or stick on the third or fourth day following injury. If a leather boot is to be worn, the heel is attached to the boot and not to the plaster.

The application of plaster-of-Paris in such a way that weight-bearing on the injured limb can be carried out soon after injury is whole-heartedly recommended. We have found the method free from disadvantages and are of the opinion that there are several great advantages pertaining to the employment of this technic.

It need not be explained that patients are pleased to be relieved from the irksomeness of confinement in bed or to the house, and that they appreciate being able to walk without crutches. It is also easily realized that many patients gain much by being able to return to work within a week or two after injury, particularly is this fact appreciated by one's private patients.

More important, however, in our opinion than the foregoing advantages is the fact that the end result obtained is more perfect than by other methods and that the period at which complete return of function of the limb is reëstablished is shorter than when other more confining methods are employed. More particularly are we of the opinion that the occasional very troublesome, painful and disabling complication, namely bone atrophy, is avoided by making

it possible for the patient to commence walking early. Time does not permit, nor is the author prepared to enter into an argument as to the cause of bone atrophy following fractures; I am, however, of the opinion that disuse is of very considerable importance in the development and prolongation of

the condition. During the past few years many cases of bone atrophy have been seen by the author. All of them have been treated by methods other than that recommended in this contribution.

The more trivial type of case, in which originally no displacement has been present, may commence walking without support from five to eight weeks following injury.

In the more severe types of injury the plaster-of-Paris cast should be removed, and reapplied every ten days or two weeks with an interval of two or three days during which baking, massage and active movements are employed. These patients should not be permitted to walk without plaster in less than eight weeks. Very frequently it is advisable to maintain fixation for a period of twelve weeks following injury.

When the plaster is finally removed, except in those fractures due to abnormal adduction or tibial flexion, the patient is instructed to have the boot tilted. For this purpose the inner border of the heel and sole is raised a quarter, or three-eighths, of an inch. Limitation of dorsiflexion



FIG. 4—Showing application of walking plaster and application thereto of felt heel.

is sometimes sufficiently marked to make it difficult for the patient to walk easily without externally rotating the limb. This tendency can be very considerably inhibited by raising the heel so that it measures one and one-half, or one and three-quarters inches in height. By this means several degrees of potential dorsiflexion is added and the patient is able to walk more comfort-

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ably and more properly. Inasmuch, moreover, as the longer of the two lower extremities is called upon to do less work than its fellow, there is a natural protection afforded, in this way, to the injured leg.

In a small proportion of cases of the most severe type, and in a somewhat larger number of cases in which for economic or other similar reasons, it is important that plaster-of-Paris be dispensed with earlier than would otherwise seem wise, the employment of a brace is indicated. For this purpose either a short caliper or an outside iron is suitable. Since the outside iron is light and performs the functions required in fractures following external rotation and abduction injuries, it is the apparatus more generally applicable. The patient wearing such an apparatus carries but little weight upon the foot or lower part of the leg, as the greater part of his body weight is directly transmitted from the boot heel to the tuberosities of the tibia. At the same time the limb is protected against torsion and bending strains.

The period of disability following fractures involving the ankle-joint, assuming adequate treatment of the case, is dependent upon, in the first place, the nature of the injury, and in the second place, the occupation of the patient. The more trivial injuries may return to practically normal function in about ten weeks following injury. In all the more severe cases at least three months is required and very frequently six months or more must elapse before the patient is in a position to return to any occupation in which the lower extremities are subjected to strain.

END RESULTS OF CARPALECTOMY *

By B. FRANKLIN BUZBY, M.D.

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THE problem of how to handle injuries of the carpal bones is one that is far from being standardized. The small series here presented brings out a few pertinent facts which are sufficient to warrant further use of the operative treatment of these conditions.

The anatomy of the wrist is of some importance in deciding upon the method of procedure. There are eight carpal bones closely adherent to each other by means of a capsule extending from the forearm bones to the metacarpals with digitations from this capsule to each of the eight bones. There are thickened portions of the capsule forming the dorsal, volar, and lateral ligaments, and also transverse interosseous ligaments uniting the bones of each row of carpals, thus forming smooth articulations for the metacarpals and forearm bones. The radio-carpal, intercarpal and carpo-metacarpal synovial sacs inter-communicate so that hemorrhage and infection in one joint level is essentially in all. Most of the motion of the wrist-joint takes place in the radio-carpal articulation. Of a total range of 90 degrees of flexion and 65 to 70 degrees extension of an average wrist only 15 degrees is in the intercarpal joint. In estimating loss of motion, however, it is far better to compare the two wrists of the patient. Ordinary intercarpal motion is only in flexion and extension but the scaphoid itself is far more mobile than this which may be one of the causes of it being the most commonly injured carpal bone—86 per cent. of 123 cases reported by Bizarro in *Surgery, Gynecology and Obstetrics*, May, 1922, and 64 per cent. of 387 cases quoted by Speed.

The blood supply is obtained from small terminal branches entering the bones by means of the ligaments at or near the periosteum, and then these immediately spread out in all directions. This vascularity is scanty at its best thus explaining the cystic areas seen in old fractures. When a fracture occurs in the middle of a carpal bone the blood supply along this line is destroyed. Almost always there is a crushing of the fragments on either side of the fracture line. Here also the circulation is interfered with and in turn the viability of the entire bone is threatened or destroyed. Absorption of the non-vascular area takes place slowly, or if sufficiently damaged in the beginning the entire bone undergoes an avascular death and if left in place acts as a foreign body causing irritation to the surrounding soft tissues and bones. Due to lessened use the neighboring bones undergo atrophy and because of the irritation of the foreign body, pannus formation may appear. Ligamentous congestion and inflammation takes place, chronic effusion appears and periarticular limitation of motion ensues even including the tendons and sheaths. The grip becomes

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END RESULTS OF CARPALECTOMY

weak and painful. In carpal dislocations the blood supply of the involved bone is soon interfered with and even though the displacement is reduced, the bone in time is very apt to undergo necrosis. Pressure on overlying nerves by the fragment soon causes interference with the intrinsic musculature of the hand, which when it arises is always very slow in recovery. This same symptom takes place when too great efforts are used at reduction, especially in volar semilunar dislocations.

The fact that in practically all unrecognized or untreated carpal bone injuries and in many treated conservatively, the above pathological changes take place it is of considerable importance that these injuries be recognized early. Any trauma of the wrist incurred in a fall on the hand or one the result of a direct blow or auto backfire should make one suspect a carpal bone injury, and should adequate X-ray pictures be taken in two planes the diagnosis is clear. Clinical findings are of value also—*e.g.*, hyperextension of wrist is painful, often lacking; the grip is weakened and attempts cause pain in the wrist. Motion continues to be more limited as time goes on and the swelling does not subside. Direct pressure on the affected bone causes pain which persists for a while after the pressure is relieved. In dislocations of recent origin there is an abnormal prominence on one aspect of the wrist, and a depression on the other with limitation of motion in all directions. It is most difficult to accurately diagnose a combined injury to two or more carpal bones but since it is sufficient to recognize the need of a röntgenogram, by this means we will be set straight as to diagnosis.

The operative treatment of carpal bone injuries can best be done using an Esmarch band and then by means of a longitudinal incision over the affected bone, careful exposure and division of the annular ligament, gentle retraction of tendons in their sheaths and incision through the capsule exposing the desired carpus. The proximal fragment of the scaphoid as a rule is easy to deliver but the distal portion seems very tenacious, especially where it is firmly attached to the lateral ligament of the wrist. If the necessary cutting or blunt dissection of the ligamentous attachment is carried out using the bone to be removed as a buffer, no damage is done to the blood supply or synovial membrane of the surrounding bones. The wound is closed in layers, a rubber tissue drain is inserted and a plaster splint is applied with the wrist in 30 degrees of extension, the position described by some as that assumed by the wrist when one grasps a tumbler.

The drain is removed at the first dressing in three or four days and the splint done away with after eight to ten days when active motion and physiotherapeutic treatment are begun. In recent cases motion is returned almost to normal and in old cases motion is greatly increased. In both types of cases pain on motion and on gripping is done away with. In any event it is the pain rather than lack of motion which is so disabling to the patient.

In a series operated upon by the writer at the Cooper Hospital, Camden, N. J., six were done within a week of the injury and four were done at periods of from seven weeks to six months after the original injury. Many other

late cases have been seen and advised operation who have refused or who have gone on to another clinic for care. Many early cases with fractures which appear incomplete röntgenologically or which appear to be merely sprain fractures, or very early dislocations easily reduced, have been seen and treated conservatively.

Speed in his monograph on "Traumatic Injuries of the Carpus" gives several positive statements which can be followed without argument: (1) All cases of old dislocations of carpal bones should have carpalectomy. (2) All cases of old fracture with displacement of fragments should have operation and removal. (3) The entire bone involved should be removed. (4) Conservative treatment should be tried first for a long period in adolescents.

Going further, it would seem that conservative treatment should be reserved for those patients with sedentary occupations. In all other cases operative treatment ought to be instituted early because the period of time loss is about equal in the two methods, and as it too often happens after conservative treatment the wrist is weak and painful and operation must be done with a double loss of time, to say nothing of the fact that the longer the elapsed period from injury to operation, the less likely we are to get a satisfactory result.

Case	Age	Occupation	Diagnosis	Cause
(1) I. M.	29	Carpenter	Comminuted fracture trapezium	Direct blow
(2) H. M.	32	Laborer	Fractured scaphoid	Fall on hand
(3) L. D.	38	Laborer	Fractured scaphoid	Fall on hand
(4) A. T.	27	Foreman	Comminuted fracture scaphoid	Fall on hand
(5) I. S.	35	Salesman	Fracture cuneiform Dislocation semilunar	Auto backfire
(6) P. H.	19	Patternmaker	Fractured scaphoid	Fall on hand
(7) L. T.	48	Retired	Dislocation semilunar	Auto accident
(8) C. K.	24	Laborer	Fractured scaphoid	Fall on hand
(9) J. S.	22	Prize fighter	Fractured scaphoid	Striking 150-lb. sand bag with fist
(10) R. B.	18	Student	Fractured scaphoid	Fall on hand

All but Cases 4 and 5 had complete removal of the affected bones. The former had excision of the proximal fragments of the scaphoid and the latter had the cuneiform removed and the semilunar replaced. These two alone have pain and that only on forced motion. Even these have a normal painless grip.

End Result.

Recent Cases.

Case	Injured date	Operation date	Time lost from work	Lost motion as compared to other hand	Pain
(1) I. M.	6/26/23	6/29/23	10 weeks	none	none.
(2) H. M.	8/1/23	8/6/23	7 weeks	30 degrees extension in 4 months	none.
(3) L. D.	8/30/23	9/3/23	7 weeks	none	none.

END RESULTS OF CARPALECTOMY

End Result.

Recent Cases.—Continued.

Case	Injured date	Operation date	Time lost from work	Lost motion as compared to other hand	Pain
(4) A. T.	9/12/24	9/15/24	1 week	15 degrees flexion 10 degrees extension 10% disability	slight on forced motion.
(5) I. S.	10/20/26	10/22/26	9 weeks	15 degrees flexion 20 degrees extension 15% disability	moderate on forced motion.
(8) C. K.	9/25/27	9/30/27	6 weeks	20 degrees extension in 5 months	none.

Old Cases.

(6) P. H.	10/20/26	12/6/26	8 weeks	none	none.
(7) L. T.	12/14/26	2/3/27	7 months	50 degrees extension	none.
(9) J. S.	7/10/27	10/31/27	6 weeks	none	none.
(10) R. B.	8/15/27	2/16/28		30 degrees extension 30 degrees flexion	none.

ACUTE HÆMATOGENOUS OSTEOMYELITIS *

THE RELATIONSHIP OF ITS PATHOLOGY TO PROGNOSIS AND TREATMENT

By FENWICK BEEKMAN, M.D.

OF NEW YORK, N. Y.

ACUTE hæmatogenous osteomyelitis is a suppurative, inflammatory process in a bone, the infection being deposited through the circulation. Consequently, for the development of a focus of osteomyelitis, it is necessary that there be bacteria circulating in the blood and that there be a point in the bone where the conditions are such that the bacteria may lodge and grow.

Undoubtedly at many times, during one's life, bacteria are freed from some focus into the blood stream, but usually they come to nought as they are disposed of by the various bactericidal agents of the blood and body cells before they can find a suitable place for lodgement. (Martin.) Thus a bacteraemia does not mean necessarily that the bacteria are constantly in the blood stream.

A focus may free bacteria into the circulation only once, in an intermittent manner or continuously, or possibly the bacteria having once gained access to the blood stream may propagate there.

The focus from which bacteria enter the blood stream may be in any part of the body. It is probably most frequent for the bacteria to gain entrance to the circulation from the surface of an infected thrombus, as one in a superficial vessel near some inflammatory process in the skin or mucous membrane.

The severity of a bacteraemia depends on the one hand on the virulence of the bacteria and the number of microorganisms set free in the blood stream, and on the other on the amount of resistance of the body.

Although in most cases of bacteraemia the microorganisms are only transiently in the blood stream, nevertheless in some there may be lesions which free the organisms continuously, as in the case of a thrombus in some large vessel, or the bacteria having gained entrance to the circulation a secondary lesion is established within the circulation as upon the surface of the endocardium.

Some writers consider the term septicæmia to mean a condition where there is a constant circulation of bacteria in the blood stream. This definition appears to be vague and for clearness of understanding the term bacteraemia will be used, at this time, to denote all cases where bacteria are actually found in the circulation, and the term septicæmia will only be used to denote a clinical entity, where the symptom complex is caused by a bacteraemia, in which the symptoms of the blood infection overshadow in intensity the signs of any local condition which may be present.

It is presumed that when a secondary focus is started in the body, whether

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ACUTE HÆMATOGENOUS OSTEOMYELITIS

it be in the soft parts or bone, that it may become the point from which bacteria may enter the circulation, as well as from the primary focus: Thus a bacteriæmia may be continued from either of these foci or both, and any further local lesion which develops whether it be in bone or soft parts may be a metastasis from either.

If during the period in which bacteria are in the circulation some of them are deposited at a point in the body where the local resistance is lowered and conditions are favorable for their growth, a focus is established, and if this point is within a bone, osteomyelitis develops.

If the bacteriæmia producing an osteomyelitis is only transitory and the new focus, within the bone, does not produce a secondary bacteriæmia, the condition will be only that of a local infection within a bone. However, if the bacteriæmia is continuous, resulting from either the primary point of invasion or the secondary lesion, the condition becomes one of a generalized blood infection complicated by an infection within a bone. In the latter case the septicæmia must be recognized as well as the osteomyelitis.

To understand the lodgement of bacteria in a bone and the development of an osteomyelitis, it is necessary to have some knowledge of the anatomy of the bones.

The fact that certain types of bones are involved more often than others and that the pathological process usually starts at a given point in them, leads us to the belief that the anatomical structure of this point, in these bones, is such that under certain conditions the bacteria are able to gain access to the tissues

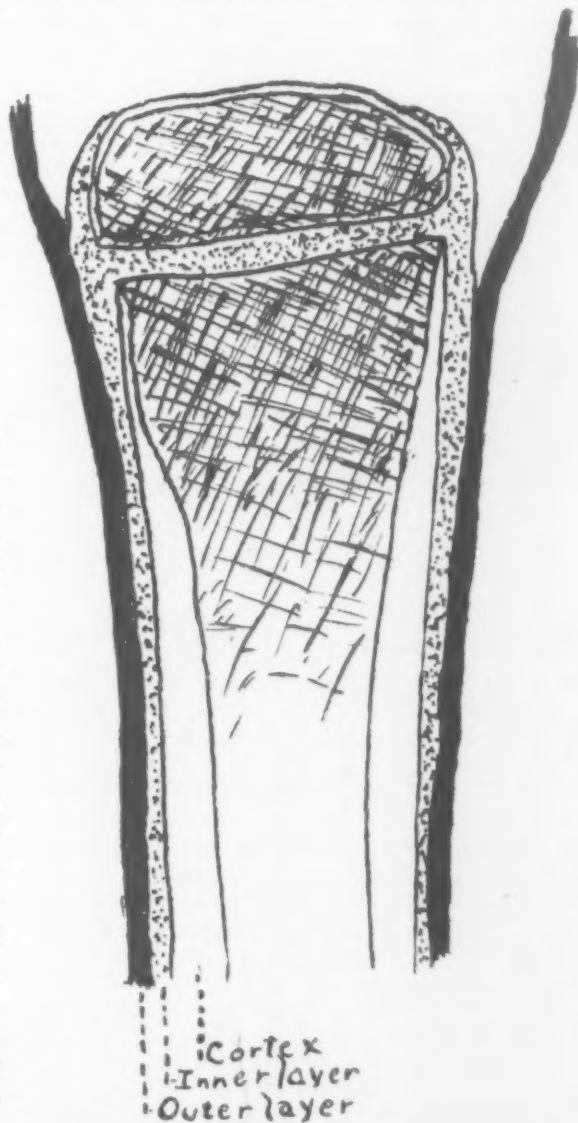


FIG. 1.—Schematic drawing, showing relation of layers of periosteum to epiphyseal line, and epiphyseal line to joint.

and start a lesion. It will be shown that the long bones are much more often affected than the flat or small bones, and that the ends of the diaphysis are the points at which the lesion is usually situated.

The long bones of the skeleton are developed from embryonal cartilage in which centres of ossification develop. At the time of birth the diaphyses of the bones are entirely ossified, while the epiphyses, with the exception of those at the lower end of

the femur and upper end of the tibia, are still entirely cartilage. One or more centres of ossification develop in the cartilage of the epiphysis, finally ossifying the entire end of the bone except for a narrow cartilage which separates it from the diaphysis, and is known as the epiphyseal cartilage, and a cap of cartilage on its extremity which becomes the articular cartilage.

The epiphyseal cartilage is made up of successive layers of cells. The layers toward the epiphysis are composed of a hyalin cartilage matrix in which are found irregularly-scattered cells with deep-staining nuclei which show numerous mitotic figures. This layer adds slightly to the epiphysis to produce its growth, but its main function is in supplying new cells for the columns of cartilage cells which form the remaining layers of



FIG. 2.—Hip-joint. The epiphyseal line of the femur is entirely intra-capsular.

the conjugal cartilage. Growth takes place from the diaphyseal side of the cartilage by proliferation of the cells in its successive layers. The cartilage cells in the outermost layer being absorbed and replaced by bone in the epiphyseal end of the diaphysis. Thus, Ollier found that the excision of the epiphysis itself, leaving the conjugal cartilage, resulted only in a slowing of the growth of the bone; the cartilage still proliferating and producing new osseous tissue.

Haas has shown, experimentally, that the cutting off of the entire blood supply to the epiphysis results in a marked lessening of the longitudinal growth of the bone; that if the nutrient artery is destroyed there will be practically no change in longitudinal growth, as long as the circulation to the epiphysis is intact; and that if both the circulation to the epiphysis and the nutrient artery are destroyed, at the same time, there will be a greater loss of growth than if only the former circulation is cut off. From these facts he reasons that, "The maintenance of the normal longitudinal growth of bone is dependent upon a sufficient blood supply to the region of the epiphyseal cartilage line."

In further experiments, to prove the localization of the growing point in the cartilage, Haas came to the conclusion that a separation in the natural line of cleavage between the epiphysis and metaphysis caused some loss in growth; that the excision of the metaphysis caused a very slight disturbance to growth, and that the excision of the epiphyseal

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cartilage caused practically a cessation of growth. He concluded that, "The most active and important elements necessary for longitudinal growth are located in the columns of cartilage of the epiphyseal cartilage plate."

The diaphysis of the bone is composed of a shell or cortex which surrounds a partly-hollowed centre which is known as the medulla; for clearness in description the diaphysis may be arbitrarily divided into a shaft and a metaphysis at either end.

The cortex is made up of compact bone which is formed of lamellæ or sheets of bone, which are placed in concentric groups surrounding the Haversian canals, which carry the blood-vessels. The blood-vessels enter the Haversian canals in the compact bone, both from its outer surface and from the medulla. The cortex of the long bones is thickest in the mid-shaft of the diaphysis and becomes thinner as the metaphyseal region is approached, where the bone broadens out.

The medulla at the end of the diaphysis is composed of a network of trabeculæ or scaffolding of cancellous bone, which forms numerous cell-like marrow cavities. As the shaft of the diaphysis is approached, the cavities grow larger and less numerous, until one large cavity is formed, which is known as the medullary cavity. The medulla contains the marrow, a highly specialized vascular tissue, and blood-vessels, together with fat. There are lymphatic trunks accompanying the vessels.

The portion of the diaphysis in contact with the epiphyseal cartilage is formed of soft spongy bone; it is red in color and very vascular; it is known as the juxta-epiphyseal region of Ollier. This is the active area of new bone formation, resulting in the longitudinal growth of the bone.

The attachment of the surface of the epiphyseal cartilage to the diaphysis is insecure, the cartilage being held in relation to the metaphysis by the periosteum. Thus separation of the epiphysis almost always takes place through the juxta-epiphyseal region, and injury to this region may result in a retardation of the longitudinal growth of the bone.

The bones are closely invested by the periosteum, which is composed of two layers, an inner or osteo-genetic and an outer or fibrous layer. The periosteum covers the entire diaphysis and is easily detached except where ligaments, tendons or aponeuroses are attached. In the young it is a thick vascular membrane, but later becomes thin and more firmly attached to the bone.

The inner or osteo-genetic layer is continuous with the epiphyseal cartilages at either end of the bone; the cartilage appearing to be a massive expansion of this layer of the periosteum. This layer produces the concentric growth of the diaphysis. As it is attached to the conjugal cartilage, it does not extend continuously upon the epiphysis. The osteo-genetic layer surrounding the epiphysis is also continuous with the conjugal cartilage, the two portions extending from the cartilage like the arms of a Y. The fibrous layer of the periosteum is made up of bundles of fibrous tissue, it acts as a protection to the delicate cells of the inner layer, and helps support the blood-vessels which perforate it. It is continuous with the peri-articular ligaments at the ends of the bones and when attached to the epiphysis is the principal bond of union between it and the diaphysis.

The articular cartilages capping the ends of the epiphyses are composed of hyalin cartilage, and are the remains of a portion of the cartilaginous epiphyses which have not become ossified. The synovial membrane which lines the joint cavity extends over

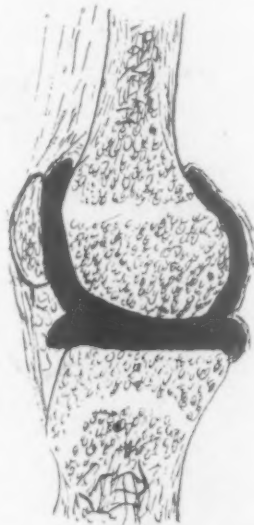


FIG. 3.—Knee-joint. The epiphyseal line of the tibia is entirely extra-capsular. The epiphyseal line of the femur is intra-capsular on its anterior and posterior aspects, and extra-capsular on its lateral surfaces.

the surface of the articular cartilage for a short distance, but is absent where the cartilages come in contact with each other.

The relationship of the attachment of the capsule of the joint to the epiphyseal cartilage differs in each joint. If the ligaments are attached to the bone proximal to the epiphyseal line, the entire epiphysis is intra-capsular, as in the head of the femur. If they are attached distal to the cartilage, the epiphyseal line is entirely extra-capsular as found in the upper end of the tibia. In many joints the epiphyseal line is intra-

capsular on one aspect and extra-capsular on another; as in the lower end of the femur, the lower end of the bones of the leg, the upper end of the humerus and the bones about the elbow and wrist joints.

The long bones, in growing individuals, receive their blood supply from three different sources. A single nutrient artery to each bone perforates the cortex of the shaft at about its mid-point, passing through the nutrient canal. (The femur has two nutrient arteries.) On reaching the medullary cavity it divides into ascending and descending branches to supply either end of the bone. These give off lateral branches which enter the Haversian canals of the cortex, anastomosing with branches from the periosteal vessels. The main branches of the nutrient artery finally end

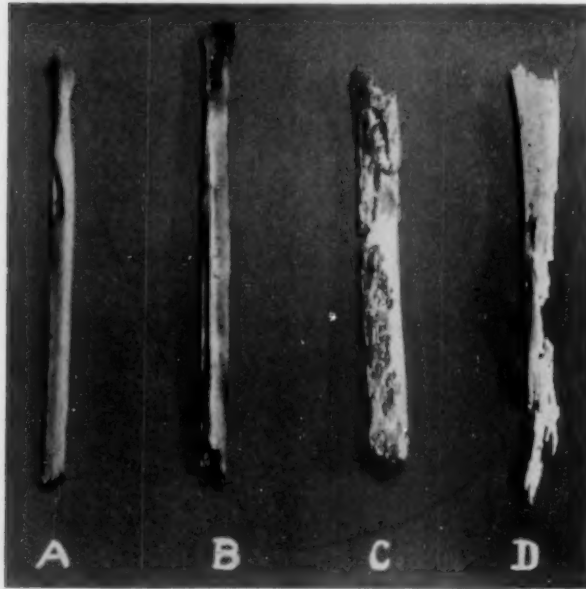


FIG. 4.—A. Sequestra of shaft of fibula removed soon after separation. Note lack of absorption of bone. B. Sequestra of shaft of fibula removed early in disease. New shaft failed to form in this case. C. Sequestra of shaft of tibia showing slight absorption. New shaft failed to form. D. Sequestra from shaft of tibia involving only two-thirds of circumference of shaft although the contents of the medullary cavity, in this case, was totally destroyed.

just short of the juxta-epiphyseal region in terminal branches which form venous loops in which the circulation is slowed. The cortex of the shaft of the bone is also supplied with blood from a network of arteries in the periosteum. These enter the bone through the Haversian canals, opening on the cortex, and supply the outmost lamellæ of bone. The periosteal vessels are short, but they anastomose with the vessels which enter the cortex from the medulla. Lexer has shown that in the metaphysis the periosteal vessels, which are larger, perforate the thin cortex supplying the portion of the metaphysis which is in relation with the epiphysis. Lexer described an avascular area in the metaphysis between the terminal vessels of the medullary circulation and the perforating periosteal arteries. But more recent investigators believe that the periosteal vessels anastomose with the lateral branches from the medulla.

The epiphysis receives its blood from vessels derived from the capsular arteries and from those in the periosteum; these perforate its thin cortex. While the epiphyseal cartilage exists, there is no communication between the vessels of the diaphysis and epiphysis within the bone. The conjugal cartilage has no blood-vessels. (The head of the femur, being entirely intra-capsular, receives its blood through the round ligament.)

The amount of circulation to any tissue depends upon the metabolic activity or work demanded of that tissue; the cortex of the bone being made up of an inert tissue, only needs nutrition enough to keep it alive, and produce its relatively slow concentric growth,

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while the metabolism of the marrow and the tissues of the juxta-epiphyseal region are very active, the former in generating new blood cells and the latter in producing the longitudinal growth of the bone, consequently the blood supply to these tissues is plentiful.

The amount of growth that takes place at either end of a bone is not the same. The canal for the nutrient artery enters the bone in an oblique manner. One explanation given for this is that the inequality of growth, at either end of the bone, causes a shifting of the periosteum, which draws the proximal portion of the nutrient artery toward the more rapidly-growing end.

The epiphysis, toward which the nutrient artery is directed, is the last to form centres of ossification, and is the first to join the diaphysis, and is consequently the end of the bone in which the least growth takes place. These epiphyses are the upper ends of the femur, and the bones of the forearm and lower ends of the humerus and bones of the leg.

The bacteria causing acute hæmatogenous osteomyelitis are the staphylococcus, streptococcus, pneumococcus, bacillus of influenza and the typhoid bacillus. The staphylococcus pyogenes aureus is most commonly found associated with this condition. Normally this organism is found in the skin and in other parts of the body. It may enter the circulation through small abrasions or wounds in the skin or mucous membranes, often without producing marked signs of inflammation at its points of entrance. Frequently the opening in the skin may be healed at the time of the onset of the osteomyelitis. Occasionally acute hæmatogenous osteomyelitis is preceded by a furunculosis. Lexer thinks that the common association of the staphylococcus aureus with osteomyelitis is probably due to the fact that it forms in clumps, which are more apt to be stopped in the loop of vessels in the metaphysis, and that the aureus is more often found than the albus, as the primary lesion is more commonly of the former variety. Robertson believes that the staphylococcus has a preference for the marrow cavities of bones.

MacCallum states, "The streptococcus seems to be able to enter readily into the blood stream by the aid of the lymphatics." Sore throats may precede lesions in the bone caused by the streptococcus hæmolyticus, or the osteomyelitis may be associated with a general pyemia produced by this organism. During the severe epidemic of influenza in 1918, osteomyelitis at times complicated the disease. The organism recovered from the bone lesion was usually the streptococcus, but occasionally pure cultures of the bacillus of influenza were reported.



FIG. 5.—Brodie's abscess, lower end of radius.

Rarely during the late febrile period or convalescence of typhoid fever, osteomyelitis may develop, most often in the ribs, tibia or femur, and cultures from the bone involvement may show the bacillus typhosus.

The staphylococcus is usually recovered from the osteomyelitis which complicates the exanthemata.

Acute hæmatogenous osteomyelitis is not a particularly common disease. Sutton reports that among 3,634 total admissions to the Hospital for Sick Children at Brisbane, there were fifteen cases of this condition, an incidence of .4 per cent. On the Children's Surgical Service, Bellevue Hospital, during the last three years, there have been twenty-seven cases of acute osteomyelitis in 3,751 admissions, an incidence of .7 per cent.

Osteomyelitis of this type is a disease found preëminently during childhood and adolescence, though occasionally a case is seen during the third decade of life. Speed, from a general service, reports 90 per cent. of his cases occurring in individuals under fifteen years of age. Pfeiffer's cases were divided according to age as follows: Six below five years, twelve between five and ten years, and seventeen between ten and fifteen years. The average was ten years. Doran and Brown in an analysis of cases in children up to the age of twelve years report 74 per cent. of their cases in children older than six. Thus it is seen that the disease attacks the bones of individuals who are undergoing active growth. This is explained by the anatomical structure and physiological conditions found in the bones at this time of life, which afford the conditions necessary for the deposition and growth of bacteria in these locations.

Boys are subject to osteomyelitis almost twice as commonly as girls. Pfeiffer had fourteen cases in male and eleven in female patients in his series, and Doran and Brown had forty-four boys and twenty-seven girls. The skin of boys is more subject to mild infections; they are not as cleanly as girls, they are more prone to have cuts, scratches and abrasions, and at puberty they often develop acne and furunculosis, any of which conditions may become the primary focus for a bacteriæmia. In addition, boys are more subject to exposure, to wet and cold and are much more apt to receive injuries such as bruises and strains.

From the clinical and pathological findings observed in patients suffering from acute hæmatogenous osteomyelitis, it is evident that the metaphysis or juxta-epiphyseal region of the diaphysis is the portion of the bone that is commonly involved. Starr and Robertson recently have shown this quite conclusively. But occasionally the medulla of the shaft or even the epiphysis may be the point in the bone which is first attacked. It has been stated that a primary suppurative osteomyelitis of the epiphysis never occurs. However, three such cases have been observed, one of which was proved by pathological examination to be an acute primary epiphysitis caused by the staphylococcus aureus. Such cases, however, would appear to be exceptions to the rule, that acute hæmatogenous osteomyelitis starts in the juxta-epiphyseal region of the diaphysis.

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The bacteria are thought to reach the juxta-epiphyseal region through the medullary arteries of the diaphysis or as Lexer states, through the periosteal perforating arteries of the metaphysis. Their progress is said to be retarded in the juxta-epiphyseal region by the physiological slowing of the current of the blood stream in the vascular loops found in this portion of the bone.

⑥ Lexer states, "That the mechanical condition provided in the epiphyseal zone of growing bone, in which there is a physiological hyperæmia with a slowing of the blood stream, and by the arrangement of smaller vessels, and capillary loops with their branches which pass down into the primary medullary spaces of the epiphyseal cartilage, favor the disposition and retention of bacteria and explains the frequency of acute suppurative lesions in this point of the bone."

②* The apparent lack of phagocytic action, against invading bacteria, of leucocytes in the metaphysis, may also account for the more common location of the lesion in the ends of the diaphysis. If the staphylococcus aureus be injected into the circulation of young rabbits, the organism will be found among other places in the shaft, metaphysis and epiphysis of the long bones. In a few hours active phagocytosis is taking place within the medullary cavity and the epiphysis, but no leucocytes containing bacteria are found in the metaphysis. Robertson reports the following result of his experiments on rabbits.

1. "Organisms introduced into the blood stream are deposited, among other places, in the long bones."

2. "In bone there is very active phagocytosis, except in the metaphyses."

3. "Organisms produce inflammatory centres in metaphyses independent of trauma."

4. "It is impossible to produce a general infection of the medulla by a simple inoculation of organisms in the blood stream."

5. "Trauma may determine a local infection."

6. "Growing bones develop abscesses of the type of osteomyelitis within their metaphysis. Adult bones do so but rarely. In presence of a bacteriæmia, adults may produce an arthritis."

③ O. Uffreduzzi believes that the location of an infection in a bone is dependent upon the amount of activity in growth of the different parts of the bone; that in the first two or three years of life the chief activity of growth is taking place in the epiphysis, that is, the cartilage of the epiphysis is being absorbed and replaced with bone, consequently there is an increased blood supply. He thinks during this period infection most often attacks the epiphysis. In the later years of life, from five years on to adolescence, the greatest activity of growth is seen in the metaphysis, and that accounts for the fact that infections during this period are located in the ends of the diaphysis. He goes on further to state that the metaphysis, which is most frequently attacked, is the one at the end of the bone which shows the greatest activity in growth. His theories are of interest, but have not all been borne out by the clinical cases seen.

In addition to the facts already presented, it is probable that a pathological change must occur within a bone, to predispose a specific metaphysis to

infection. In other words, there must be formed a "*locus minoris resistentiae*." Cold, exposure, debilitation from infectious diseases are all given as possible predisposing causes, and may have somewhat to do with lowering the general resistance of the body, but local trauma appears to be the agent which most often renders susceptible a point in a given bone to the infection. A history of injury to the part is obtained, in a large number of cases. This



FIG. 6.—Pathological fracture through the lower metaphysis of the femur, two weeks after the onset of the disease. Suppurative arthritis of knee-joint.

is usually a story of slight direct violence, as a kick, or a bruise from a fall, but occasionally the patient may tell us that he "strained his leg" from jumping or running. Pfeiffer, in his report of thirty-five cases, obtained a history of trauma in 43 per cent. Bancroft states that in eleven cases, 60 per cent. received injuries, varying in time from ten hours to two weeks, before the onset of the acute process. A child has been seen by us, who had the lower epiphysis of his radius dislocated, which was reduced, and two days later returned to the hospital with an osteomyelitis in the metaphysis from which the epiphysis had been dislocated.

The predisposition of a bone to infection with the staphylococcus by trauma can be produced experimentally, as shown by Robertson, and Zinsser states, "Intravenous injections of virulent staphylococci preceded by injury to a bone is often followed by the development of osteomyelitis." Direct violence to or a twisting of the limb, by which a slight movement of the epiphyseal cartilage, on the metaphysis, is produced, causes the rupture of some of the small vessels of the metaphysis, thereby interrupting the blood flow in them and producing a haematoma. With this obstruction to the passage of blood through the vessels, and

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an extravasation, there is formed a point favorable for the lodgement and growth of any bacteria that may find themselves in the region.

Robertson believes that the type of injury producing conditions favorable for the development of osteomyelitis must be one that results in a movement of the epiphysis upon the surface of the metaphysis, and that this is the result of traction upon the epiphysis through the ligaments which are attached to it. This may be one of the explanations of the frequency of osteomyelitis in the upper end of the tibia, as all of the ligaments of the knee-joint are attached to the epiphysis, and the joint being immobile except to flexion, any forced motion of rotation, abduction, adduction or extension, will be transmitted to the epiphysis. These same restraining ligaments are for the most part attached to the diaphysis of the femur, and consequently movements of its epiphysis upon its shaft are not as likely. It is more difficult to ascribe an injury by this method to the upper epiphysis of the femur, as this part of the bone is entirely intra-capsular, and the only ligament attached to it is the relaxed round ligament.

The bones of the lower extremity are involved far more often than those of the upper. Infection of the tibia occurs in about a third of all the cases, while the femur is involved in approximately a fifth; then follows in order of frequency the humerus, the fibula and the radius and ulna. The reason for the more frequent involvement of the long bones of the lower extremity is that they are much more subject to injuries than those of the upper. These facts may also be used to advantage to strengthen the view that trauma is a predisposing factor in the production of this disease.

✓ The individual metaphysis attacked varies with the bone. As a general rule, it is stated that the end of the bone whose epiphysis is the last to join the shaft is the one most frequently involved; the ends of the bones of the lower extremity which form the knee-joint, and the ends in the upper extremity which are distal from the elbow-joint. Starr found the upper end of the tibia the most common site. Doran and Brown had eighteen cases of the lower end and but eleven at the upper, and Pfeiffer had ten of the former and only one of the latter. Nevertheless, most writers state that the upper metaphysis of the tibia is the commoner site in the majority of cases. The lower end of the femur is involved about three times as often as the upper. In the upper limb the upper end of the humerus and the lower end of the bones of the forearm are the joints of election.

Multiple bone involvements are seen in about 15 per cent. of the cases. (Speed 16 per cent., Pfeiffer 9 per cent., Doran and Brown 14 per cent.) It is not usual to have two bones involved at the onset of the disease; however, a secondary involvement may develop within a few days or a week. At times the period between the onset of the first bone infection and the second is even longer than this. In a few cases secondary involvements of bones are stretched over periods of many years. A case may be mentioned of a boy of fifteen years of age, who had had five different bones attacked since the onset when ten years old.



FIG. 7.—Early suppurative arthritis of knee-joint following small lesion in the lower metaphysis of the femur.

In those cases in which secondary bone involvement takes place, the amount of damage done the bone and the severity of the symptoms are not as great in the later attacks as in the first. It appears that the body becomes partially immune to the organisms. It is interesting to speculate as to the origin of the bacteria causing a secondary bone involvement. We presume that they come from the blood, as in the case of the primary bone involvement, but do they enter the blood stream from the original focus or from one of the secondary lesions? With our present knowledge it is impossible to say which focus they come from, but it is conceivable that either may be the origin of the new bacteriæmia, producing the metastasis. Wilensky states that preceding a metastasis there may be a lightning up of the local symptoms in one of the old lesions, and that the bacteria producing the new focus enter the circulation from this lesion of renewed activity.

In considering the pathological changes which may take place in a bone infection of the type of hæmatogenous osteomyelitis, there are several factors which must be borne in mind. The

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first is that it is not an infection of a single tissue—*i.e.*, bone—but of a structure composed of multiple tissues. The centre of which contains soft, highly specialized, vascular tissue, the marrow, which is surrounded by a dense non-expansile wall, which is invested with a strong fibrous membrane, the periosteum, and at either end of which are the epiphyseal caps separated from the shaft by an avascular wall of cartilage. The second factor is the arrangement of the arteries, which are centripetal in their relation to the flow of blood. The main portion of the circulation to the shaft entering from the periphery by a single vessel immediately divides to be distributed to either end of the medullary cavity. And the remaining entering the diaphysis by the perforating arteries of the periosteum supply the outermost portion of the cortex except at the metaphyses where they perforate the thin cortex to supply its cancellous bone. It is to be remembered that the blood supply to the epiphysis is quite separate from that of the shaft; the conjugal cartilage acting as a wall between the two circulations. Therefore it is seen that the circulation entering the bone flows from its periphery to its centre, and any condition that interrupts its flow at the periphery of the bone will produce an ischemia at its centre.

It has already been stated that the development of acute hæmatogenous osteomyelitis depends upon the presence of virulent bacteria circulating in the blood stream, and a localized point of lowered resistance in a bone where they may be interrupted and held. Consequently, the general resistance of the body must be lowered enough to allow the bacteria, which are present in the blood, sufficient time to circulate in its stream to reach a point where they may be interrupted in their passage, and that this point be one of lowered resistance. It has been shown that this point is usually in the metaphysis of a long bone.

The bacteria having been deposited in such a location, grow and multiply, producing a small area of necrosis and liquefaction due to the action of their endotoxins.

If the bone be examined at this time, a small focus of broken-down tissue will be found in the metaphysis, surrounded by zones of leucocytic infiltration and hyperæmia. If near the circumference of the bone, the periosteum over this point will be congested, œdematous and perhaps separated from the cortex by a serous exudate.

Spread of the infection, with death of bone, is the result of interference with the circulation, producing an ischemic necrosis. In a bone in which infection is not present, interference to either the medullary or periosteal circulation alone does not result in death of the bone. For example, removal of periosteum from comparative large surfaces of cortex does not produce a sequestration of the circumferential lamellæ at that point. And in fractures of the shaft of a bone with displacement of the fragments, in which the medullary circulation to the fragment distal to the nutrient foramen is undoubtedly cut off, there is no necrosis, though occasionally some atrophic changes may be seen in the bone structures by a röntgenogram as demonstrated by Bancroft. In the former case, where the periosteum is removed,

the outer portion of the cortex probably receives its blood through the anastomosis of its vessels with those from the medulla. While in the latter case, where the entire medullary circulation of one part of the bone is interrupted by the fracture, the circulation to the distal fragment is continued through the connections between the periosteal vessels and those of the medulla. Therefore it is probable that in osteomyelitis, the production of necrosis with sequestra formation is not altogether due to interference with either the periosteal or the medullary circulations alone, but to the embarrassment of both in combination, the result of infection.

Ritter and Wilensky believe that the necrosis is due to the lodgement of an embolus in a vessel. The extent of the necrosis depending upon the size and situation of the vessel plugged by the clot. Wilensky calls this a "thrombo-embolic phenomena," and groups the lesions as follows:

"A group of cases of sub-periosteal abscess which are based upon an acute osteomyelitis in the superficial cortex of a bone of slight grade and extent.

"A group of cases of acute osteomyelitis in which the main stem of the nutrient artery forms the fixation point and becomes occluded by the thrombo-embolic process, and in which as a consequence the entire diaphysis becomes involved in the pathological process; maximum lesions occur. This group is recognized röntgenographically by the sequestration of the entire diaphysis of the bone.

"A group of cases of acute osteomyelitis in which one of the primary divisions of the nutrient artery is caught in the thrombus-embolus formation. These are recognized röntgenographically, as well as during operation, when the involvement of the shaft of the bone occurs through the entire thickness of the shaft at one end of the diaphysis, approximately, to one or the other side of the point of entrance of the trunk of the nutrient artery. Such cases are easily recognizable in the X-ray photographs.

"A group of cases of acute osteomyelitis in which the thrombus-embolus formation occupies one of the secondary branches of the nutrient artery. These are recognized röntgenographically, and during operation when the involvement of the diaphysis does not extend throughout the thickness of the shaft of the bone. These seemingly follow no rule in their development, are of irregular size and shape, frequently correspond to a thin shell of the cortex of the bone, occupy only a relatively small segment of the circumference of the bone, and depend for their physical characteristics and röntgenographic appearances upon the position of the secondary branch, its importance in the intra-osseous vascular network and upon the possibilities of collateral circulation.

"A group of cases of acute osteomyelitis in which the thrombo-embolic lesion is situated in the terminal part of an end vessel of the intra-osseous vascular network. The röntgenological appearances of the finished lesion is that of a cavity in the bone."

This theory of mode of onset is at variance with the etiology and pathology as seen by others. And is not borne out by the clinical and pathological signs as usually found. Besides, as already stated, the stoppage of a vessel of the medullary circulation alone can hardly result in such wide destruction of bone as Wilensky describes, as much blood is received by the bone from the periosteal perforating vessels at the metaphysis. Necrosis of bone may sometimes in severe cases possibly precede the advance of the infection.

The destruction of the periosteal circulation results most frequently from its separation from the surface of the cortex by means of products of inflammation which spread beneath it, having reached there by perforating the

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cortex. While the medullary circulation embarrassment is possibly the result of an advancing thrombus formation within its vessels.

There is some question of how much, if any, intra-medullary pressure is produced by the presence of infection within a bone. It seems probable that there must be some increase of the intra-medullary pressure, as even in abscesses in the soft parts, exudates may be found under tension. Consequently, within a bone, with its rigid walls, there must be some rise of tension. Increase in intra-medullary pressure is usually stated to be accountable for the severe pain and intense constitutional symptoms seen so often in these cases.

A point of infection having been established, in a metaphysis, it may spread in one of two directions or in both; that is, it may travel directly out toward the periosteum or into the shaft.

However, at times, a point of infection, which has started in a metaphysis, may produce sufficient reaction in its vicinity to prevent a further spread; resulting in a walled-off abscess within the cancellous tissue. In time this abscess cavity becomes surrounded by a wall of compact, ebonated bone which is lined with granulation tissue. This condition was first described by Sir Benjamin Brodie in 1830, and is therefore known as a Brodie's abscess. Henderson and Simon reported thirteen cases of Brodie's abscess from the Mayo Clinic, and collected reports of other cases from the literature, making 200 in all. Of these 200 cases, 69 per cent. of the abscesses occurred in the tibia, 10.5 per cent. in the femur, 10 per cent. in the humerus, 2.5 per cent. in the radius, 1 per cent. in the ulna and in 7 per cent. of the records the site was not mentioned.

Of the thirteen cases from the Mayo Clinic, the duration of the disease previous to admission was from five weeks to fourteen years. In the eight cases in which cultures from the lesion had been recorded, five were reported sterile and three contained staphylococcus albus. Taking into consideration the morphology, duration, and bacteriological findings, it is apparent that a Brodie's abscess represents an early stage of osteomyelitis which has been walled off by the local resistance of the individual's tissues.

An infection starting in the metaphysis and spreading toward the periphery of the bone may advance by thrombosing the periosteal perforating vessels. Starr believes that it rapidly breaks through into the line between the epiphyseal cartilage and the metaphysis and being limited by the cartilage travels out to beneath the periosteum. In most of the cases in which he has shown this to be the route, the original lesion was situated in the metaphysis close to the cortex. The infection, having reached the sub-periosteal space, separates the membrane from the surface of the diaphysis; the sub-periosteal space is limited at its ends by the attachments of the osteo-genetic layer to the epiphyseal cartilages. In the end of those bones, in which the epiphyseal line is intra-capsular, the periosteum being only composed of one layer (the osteo-genetic), the membrane may be perforated by the exudate and the joint infected.

If the infection spreads down into the medullary cavity of the shaft,

which often occurs rapidly, its course is probably by means of the formation of an advancing clot within the medullary vessels. The marrow cavities of the metaphysis being so complicated and their walls so dense it seems hardly possible that the infection reaches the medulla by means of their continuity.



FIG. 8.—Specimen of lower end of femur. In the internal condyle there is a perforation from a primary lesion of an acute suppurative osteomyelitis of the epiphysis which produced a suppurative arthritis. Probe is in the opening of perforation.

metaphysis directly to the epiphysis through the cartilage. Hyaline cartilage is quite resistant to acute infections and as there is no communication between the circulation within the metaphysis and that within the epiphysis, the cartilage forms a barrier between these two parts of the bone.

Infection which has reached the sub-periosteal space rapidly separates the membrane from the bone forming a sub-periosteal abscess which continues

Starr believes that the medulla is most often infected from a sub-periosteal inflammation spreading through the Haversian canals into the cavity of the bone. Possibly this way of extension of the process takes place at times. Recently in two cases with acute osteomyelitis of the tibia, one with the original focus in the upper metaphysis and the other in the lower, developed new lesions in the opposite ends of their diaphyses; in both cases the periosteum had been separated by a sub-periosteal abscess for the entire length of the diaphysis. The new lesions were apparently separated from the original foci by normal medullary tissue. In other words, there was no demonstrable line of extension within the medullary cavities. Possibly the new lesion developed from the blood.

It is probable that infection seldom, in its early stages, passes from the

to separate more periosteum until drainage is established either by the exudate breaking through the periosteum into the soft parts or by its relief by operation. The separation of the periosteum is preceded by a congestion of its vessels and œdema of its tissues. A complete separation of the periosteum involving the entire surface of the diaphysis will result in a sequestration of the entire diaphysis as the total circulation to that part of the bone has been interrupted at its periphery. If, however, the periosteum be separated from a smaller surface of the bone and the nutrient artery be not damaged, the resulting death of bone may be only the outmost lamellæ of that portion of the cortex from which the periosteal vessels have been removed. A sequestrum of a complete diaphysis occurs but seldom, if ever, as the metaphyses receive much of their blood from the perforating vessels of the periosteum. Usually the line of separation of the shaft takes place just proximal to the metaphyses. Large areas of sequestration take place less commonly in the metaphyses than in the shaft. This is probably due to the fact that the metaphyses are better supplied with blood-vessels than the shaft, that the cortical surface of the metaphysis is greater in proportion than that of the shaft and that the many tendonous attachments on its surface, binds the periosteum more firmly to its surface, preventing widespread separation of the membrane. However, where the periosteum has been stripped from the entire metaphysis and the intra-medullary circulation to it has been cut off, the whole metaphysis may sequestrate. In this case it separates at the epiphyseal line, often leaving the conjugal cartilage intact and undamaged.

The tibia is said to be the bone whose shaft is most frequently sequestered intact. Speed explains this frequency by assuming that the periosteum is not stripped where muscles are attached, for where the periosteum cannot be stripped as in the femur the nutrient artery is not so apt to be destroyed, while in the tibia which has few muscular attachments, the periosteum is easily separated allowing the entire circulation to be cut off.

The destruction of the intra-medullary circulation alone, without involvement of the periosteum, results oftentimes in sequestra formation of the thick cortex of the shaft, but this may not always be the case as frequently sequestra are removed in which the entire medullary cavity has apparently been destroyed, but the dead fragments of bone does not represent the entire circumference of the shaft. From a theoretical standpoint portions of the cortex of the shaft may be kept alive through the collateral circulation derived from the anastomosis between the periosteal vessels and the cortical branches derived from the intra-medullary vessels. Separation of the periosteal vessels and the destruction of the intra-medullary circulation to a given portion of the cortex will always result in death to that part.

The epiphyses are seldom involved, early in the disease, secondarily from lesions of the metaphysis. As already mentioned, when a metaphysis sequestrates the line of separation is through the juxta-epiphyseal region, and such a sequestration does not necessarily destroy the function of growth of the epiphyseal cartilage. Occasionally the epiphyseal cartilage may later be

damaged resulting in a suppression of longitudinal growth in the bone. If the bone with such a lesion is single, the limb in time will be shorter than the other. If the bone involved is paired, valgus or varus deformities will be produced at the joint, in the neighborhood of the destroyed epiphyseal line; as growth ceases in the end of the bone with the damaged epiphysis while the extremity of the companion bone proceeds with its normal growth. Or the healthy bone may become curved, its shaft bowing so as to accommodate its length to that of the diseased bone. In 1912, Martin, presented before the New York Surgical Society, a girl, twenty years of age, in whom there was an arrested development of the radius, resulting from damage to its epiphysis by an osteomyelitis, when she was a year of age.

"The affected forearm was about one-fourth the size of that on the opposite side and was curved to the radial side. The hand on the affected side was about the size of the hand of a child of three or four years.

"An X-ray plate showed that the shaft of the radius was represented by only a small thin portion of bone; the ulna was fairly well developed, but had grown in a curve toward the radial side."

Speed cites several cases of deformities, the result of injury to the epiphysis.

Joints contiguous to bones with lesions of osteomyelitis may be involved either early or late in the period of the disease. Signs of a joint infection are often the first symptoms apparent in cases where an early bone lesion has perforated into the joint; as in a case where the lesion has started in a metaphysis, in which the epiphyseal line is intra-capsular, or in a lesion within an epiphysis. As an example of the former, acute suppurative arthritis of the hip-joint is commonly seen, the lesion causing the arthritis being in the upper end of the femur. This type of case may often be demonstrated by means of a radiograph some weeks after its onset.

Late joint infections are usually due to a secondary involvement of the epiphysis. Starr states that joints are frequently infected during an osteomyelitis through operative procedures.

Occasionally a joint in proximity to a lesion of osteomyelitis in a metaphysis will contain a sterile serum. Such a condition must not be mistaken for one of an early joint involvement. The serum will be absorbed when the bone lesion is properly drained.

When a sub-periosteal abscess perforates the periosteum, it forms an abscess in the surrounding soft parts, separating planes of tissue and may finally point under the skin. A sinus resulting from spontaneous rupture as well as one from incomplete opening is frequently long and tortuous, as the pus in pointing takes the path of least resistance which often carries it along a tissue plane leading well above or below the position of the original focus in the bone.

As in the destructive period of osteomyelitis, the amount of damage to the part is dependent upon the amount of circulation involved in the inflammatory process; in like manner the reparative process is contingent on the

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amount of blood supply remaining to the different tissues of the bone after the progress of the infection has ceased.

In this latter period the organism must rid itself of destroyed tissues and replace them with healthy ones, if the normal function of the part is to be continued.

During the constructive period the dead bone is sequestered and the body attempts to remove it, simultaneously it builds up a wall of new bone, the involucrum, by means of the osteo-genetic cells of the periosteum.

It is not possible to determine, before complete sequestration has taken place, the amount of bone that has been killed. Cotton states, "Often I have seen what I thought a wholly dead fragment yield only a scale of sequestra, and then go on to do its part in repair." And Bancroft, from experiments and the study of his clinical cases, found that it was impossible in an early stage of an acute osteomyelitis to tell at what point the separation between living and dead bone might take place, and further he came to the conclusion that much of the bone which was apparently destroyed acted as a scaffolding in which new bone is formed. Similar observations have been made in the study of cases on the Children's Surgical Service at Bellevue Hospital, and a further conclusion has been drawn that the presence of a sequestra is important to the part in preventing deformity as it acts as a splint until the formation of a firm involucrum has taken place. Cases in which the sequestrum has been removed at too early a period have resulted in a pathological fracture of the bone.

Pathological fractures through the metaphyses have been seen on several occasions. This apparently occurs soon after the onset of the disease in those cases in which there has been a diffuse involvement of the end of the diaphysis. The metaphysis being made up of cancellous bone, disintegrates rapidly, leaving no long sequestrum to act as a splint until the involucrum is formed. As an example the following case may be mentioned. A boy was admitted to the wards at Bellevue Hospital, with an acute osteomyelitis of the lower end of the femur, the knee-joint became involved. Shortly afterward it was discovered that a supra-condyle fracture had occurred. After reduction recovery was rapid.

Nature removes the sequestra by absorption of the dead bone through phagocytosis and by extruding fragments through the sinuses. The action of the phagocytic cells upon dead bone fragments is well seen in the "moth eaten" or "honey combed" appearance of old sequestra. It seems that the medullary function is the absorption of the sequestrum while the periosteal region has to do with replacing the bone. (Ochsner and Crile.)

The involucrum is formed on the inner surface of the separated periosteum. The function of the osteo-genetic layer of the periosteum commences almost immediately after the membrane has been separated from the bone, but is not in evidence, by the X-ray, until calcium salts have been deposited which takes a period of from three to four weeks.

If the osteo-genetic layer of the periosteum be damaged its function of

producing new bone is lost, and the involucrum at this point is absent. At times shafts of bones which have sequestered are not reformed. Such was the condition in a case of osteomyelitis involving the tibia in which the shaft sequestered with an incomplete formation of an involucrum. It had been



FIG. 9.—Acute osteomyelitis of the right tibia with destruction of its lower epiphysis. Deformity produced by loss of growth at the lower end of the tibia.

noted at the original operation that the periosteum was gangrenous. It is thought by Dean Lewis that failure in the formation of an involucrum is especially apt when a sub-periosteal abscess has ruptured through the periosteum and has separated it from its surrounding soft parts, thus depriving the membrane of its blood-vessels.

Where the bones are paired, an inflammation of one of them may produce a non-infectious periostitis in the other, resulting in a much thickened cortex. This is most often seen where there has been an osteomyelitis of the tibia, involving the shaft, when the fibula may show periosteal proliferation by X-ray.

Where a local focus within a metaphysis has perforated the cortex producing a diffuse separation of the periosteum, new bone may be laid down upon a perfectly normal shaft, irregularly thickening its cortex. At times such a deposit may obscure the texture of the bone to the X-ray. This fact must be borne in mind, when studying a röntgenogram, to discover the extent of the disease within the bone.

At times the growing zone of a bone is stimulated to increased activity. This is evidenced by a lengthening of a limb. This condition has frequently been noted in children who had had a fracture of the femur. In osteomyelitis the same condition may be produced. Recently a little girl was seen, who, three years previously, had suffered from acute osteomyelitis of the left tibia; most of its shaft had been involved. When examined her leg was found to be two centimetres longer than its fellow. Speed has reported several such cases and draws attention to the fact that in the case where there are paired bones, the companion bone is lengthened as

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well as the one that had been involved by the infection. He believes that the congestion in the neighborhood of the juxta-epiphyseal region is accountable for the increase of growth.

It has been noted on several occasions that the bones of a limb, one of which had been involved by acute osteomyelitis, failed to grow, its parts being smaller than those of its fellow, and the actual bones, as shown in the X-ray, though perfectly formed were smaller in all proportions than the same bones of the opposite limb. A child, three years old, was seen, who, when a year of age, suffered from acute osteomyelitis of the upper end of the femur. There had been a luxation at the hip-joint, and now the leg and foot of that extremity though perfectly formed are smaller than those of the opposite side. There is three-fourths of an inch difference in the length of the two feet. In Martin's case, which has already been cited, there was an atrophy of the hand. This condition is apparently a trophic atrophy, the inflammation in the limb influencing the conditions governing the growth of the part.

In laying out a plan of treatment, in a case of acute osteomyelitis, one should attempt to visualize the pathology of the case before him. It should be decided first whether the local bone lesion is all that is present or whether it is accompanying a general blood infection. Further whether the infection in the bone is localized or progressing to involve most of the diaphysis, whether the cortex has been perforated forming a sub-periosteal abscess or the infection has spread to involve the neighboring joint, and finally what is the constitutional resistance of the individual to the infection. Some of this knowledge can be discovered from the history of the case, physical examination and immediate laboratory tests, further is obtained at operation and from the individual's reaction following operation together with the report of the findings of the cultures from the lesion and blood stream. This will make up the complete information obtainable at this time; that is until an X-ray examination will be of use.

As may be gathered from the description of the pathology of this disease, the symptoms may vary in intensity from those of an overwhelming septicæmia to those of a well localized bone abscess.

The prognosis is not always dependent upon the intensity of the disease, for many times treatment properly applied, in the form of an early operation, has apparently saved life, shortened convalescence or prevented deformities. The mortality is highest in those patients showing an active bacteraemia and in the very young.

In any case of acute osteomyelitis the first indication for treatment is the elimination of the focus from which the bacteria are entering the blood stream. In the case of staphylococcus this focus is probably the bone lesion. Where the streptococcus is concerned the lesion is probable in the upper respiratory tract or within the circulation itself. Dean Lewis says:

"Streptococci, when introduced into the circulation, seem to use the blood as a culture media—; while staphylococci use the blood as a means of transport."

Therefore it may be impossible to even attempt the elimination of the focus

producing the blood stream infection in certain cases of streptococcus infection. But in the case of the staphylococcus the focus is often demonstrated although its complete elimination can not be brought about at once.

The immediate complete elimination of the infectious lesion, within a bone, is not possible unless such a radical procedure as an amputation of the limb or possibly the resection of the complete diaphysis is performed, and in the latter case infected tissue will probably be left behind. On this basis, not so many years past, complete resection of the diaphysis of a bone in acute osteomyelitis was advised by many surgeons. In but few cases could this have resulted in immediate cure of the infection, and in addition it led to a long post-operative convalescence and frequently marked deformity. In most cases this type of operation was not indicated and much tissue that would have otherwise remained viable was sacrificed. At times complete regeneration of the shaft did not occur. At other times angular deformities and shortening took place in the limb, and occasionally the epiphyseal cartilages were damaged with the resulting loss to the bone of its function of growth.

It was not so long ago that most of us were stripping the bone of its periosteum, removing one side of the cortex over a large part of the diaphysis, and in some cases curetting out the medullary contents, the so called "gutter" operation, thereby depleting the bone of the little circulation left by the infectious process. Amputation, resection of a diaphysis, and curetting the medullary cavities are radical procedures which are followed in most cases by deformities which can be directly ascribed to the operative procedure, and are only mentioned to be condemned. (Amputations are undoubtedly indicated at times to save life, in certain cases of prolonged sepsis.) The deformity of an amputation is evident. Those following a resection of the diaphysis have already been cited. And the permanent sinus leading to a bone cavity or the broad adherent scar, poorly vascularized and frequently breaking down are common sights to us all; a reminder of the "gutter" operation based as it was on a faulty knowledge of the anatomical structure of a bone and the pathology of osteomyelitis.

As far back as 1911, Homans wrote as follows:

"I have purposely refrained from discussing at any length the refinements of treatment in complete sub-periosteal resection, because I have been unable to see that the results differ very essentially whichever method is used, though, for reasons which will appear later; I cannot believe that any real advantage of the immediate resection outweighs its danger of failure. This brings me to the matter which seems to me far more important than the resection of totally necrotic bone, a step which, like amputation, is, in a way, a confession of failure. I allude to the treatment of the cases in which the disease has remained local, or in which it has not yet infected the entire medullary cavity. Here the primary operation, the one performed when the surgeon first sees the patient, is of the greatest importance, for it is upon this that the excellence of the ultimate result really depends."

He then states that the early operation has for its object the saving of life and the limitation of infection, and reports two cases in which he had removed a small portion of the cortex and drained, obtaining excellent results.

Cotton in his article, after deploring the fact that there is no "ideal" operation, says in reference to early treatment of acute osteomyelitis, "What one should do, of

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course, is to relieve the local abscess, relieve local tension, avert ischæmic necrosis, save the threatened bone. In other words drain." And later he strongly advises against performing a sequestrectomy until the X-ray shows bony regeneration from the periosteum.

This is sound advice and all that could be added to it is that in the operative technic, care should be taken to obtain the required drainage with as little damage as possible to the remaining blood supply of the bone. As death of the bone, in acute osteomyelitis, is dependent upon ischæmia, produced by the infection, the axiom to follow: "ELIMINATE THE INFECTION" should be "IN THE OPERATION DO NOT NEEDLESSLY DESTROY MORE BLOOD SUPPLY." Consequently any operative procedure undertaken should be such that the cavity of the bone is drained with as little destruction as possible to the periosteal and medullary circulations.

The requisites for the successful treatment of acute hæmatogenous osteomyelitis are an early diagnosis, an early operation, sufficient drainage of the infected portion of the bone performed with as little damage to its circulation as possible and properly combating the blood infection.

We all know that frequently patients suffering from acute osteomyelitis are treated for days as acute rheumatic fever. To the medical student and physician it should be taught what are the early symptoms of an osteomyelitis; that the only local sign in the beginning is a point of tenderness over the diaphysis of the bone, and that by the time swelling and redness of the part appears, the infection has usually advanced into the medulla and out under the periosteum. Starr lays particular stress on the fact that pus will generally be found in the bone under the point where the tenderness has been demonstrated. We still frequently hear physicians say that as the X-ray showed a normal bone structure they did not think the case was one of acute osteomyelitis. The röntgenogram will not show inflammatory lesions within a bone until lime salts have been absorbed, producing a rarefaction of the bone, or new bone has been formed by the osteo-genetic layer of the periosteum. This does not take place until two or three weeks after the onset of the disease, and consequently the X-ray is of little or no use in making a diagnosis in the early stage of an acute osteomyelitis.

Operation should be performed as soon as the diagnosis is made. The point of maximum tenderness over the bone should be ascertained before the child is placed under an anæsthetic. The incision should be planned so as to drain directly the infected point within the bone, without damaging important structures overlying it. It should be placed over the point of maximum bony tenderness. The incision in the soft parts should be sufficiently long. The incision into the periosteum should be relatively shorter, and the membrane should, under no circumstance, be stripped from the bone further than it is already separated. The bone should be drilled in several places with a quarter inch bit. If pus is obtained a small trap-door can be opened into the bone with a gouge. Under no circumstances should the contents of the medullary cavity be disturbed. Though pus be found under the periosteum the bone should nevertheless be opened. If on drilling the bone,

pus, under only slight pressure, is obtained without blood, the probabilities are that the medullary circulation at this point is destroyed. If a few drops of pus are evacuated followed by free bleeding the probabilities are that the infection has not produced marked destruction within the bone.

Frequently mistakes are made in diagnosis. Bones have been drilled and no lesion found. The medullary cavity has been opened to find it normal and pus later has been discovered in another part. In such cases the normal tissue exposed at first has not been infected by the pus from the second opening. Starr advises that the drill holes be made as close to the epiphyseal line as possible. Though we have attempted to do this we have found, from experience, that the holes are usually some distance from the cartilage. This has been apparently due to fear of damaging the epiphyseal cartilage.

It has been found that in cases in which the medullary cavity has been involved, that incisions, such as described for early cases, placed at either end of the shaft of the bone will usually successfully drain the infection within the shaft. In these cases, after operation, the temperature will fall and though they may drain for some time there will be no signs of sepsis, unless the opening in the bone becomes obstructed by the contracture of the wound of the soft parts. This condition can be easily overcome by enlarging the opening of the sinus.

Since we have given up the more radical incision, the period of time until healing is complete, in individual cases, has apparently been shortened; the sequestra has been smaller in size; the bone, when finally healed, has shown less sclerosis and there has been a smaller scar and more soft tissue covering the surface of the bone than formerly.

It is impossible to sterilize the medullary cavity by means of the Carrel-Dakin technic, but we have placed Carrel tubes in the wounds of the soft parts as we find that irrigating, with Dakin's solution, liquefies the exudates and allows freer drainage from within the bone.

Where a joint has been involved, early in the disease, it should be drained. The position of the bone lesion, in most cases, is impossible to place and consequently cannot be drained. We have found, however, that in the majority of such cases the drainage of the joint is sufficient.

Placing the limb at rest is of importance. Homans in his article in 1911, lays stress upon this, and recently Orr has emphasized its importance in the treatment of osteomyelitis and infected wounds. The part should be immobilized in proper splints or possibly by suspension with slight traction. The disadvantage of using the circular case is that the wound and surrounding skin cannot be properly cleansed and secondary infections are apt to occur. In addition to the good effects of immobilization on healing, splinting is of importance so as to have the parts in proper position when repair is completed.

It must not be thought that treating the local condition is all that is required. Increasing the general resistance of the individual is of great moment. Rest, fresh air, and proper feeding are necessarily included. Fluids should be forced, when necessary hypodermoclyses should be resorted to, to prevent blood concentration. Multiple blood transfusions have been very

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beneficial in combating sepsis and we feel that many of our patients owe their recovery to this form of treatment, especially where there has been an active bacteriæmia. In every case a blood culture should be obtained before or at the time of operation.

It seems needless to say that no attempt should be made to remove sequestra until the X-ray shows a strong involucrum and a complete separation of the necrosed bone. Sequestrectomies should be performed through small incisions, due respect being paid to the blood supply of the diseased bone.

In conclusion emphasis must be laid on the fact that it is the patient, and not the disease, that should be treated. No two cases of acute hæmatogenous osteomyelitis are exactly alike. The disease may vary from that of a well-localized focus to one in which the lesion within the bone is but a part of a general circulatory infection. The intensity of the disease is dependent upon the virulence of the infecting organism in relationship to the resistance of the individual.

As a rule children have strong resisting powers to bacterial invasions, and are not handicapped with organs which have been damaged by the wear and tear of life. Growing tissue has a reparative power greater than that found in mature bodies, consequently deformities in the child stand a better chance of approaching the normal than those in the adult.

When it is all said and done, to obtain the best results, the proper treatment of acute hæmatogenous osteomyelitis is dependent upon a knowledge of the pathology of the disease and sufficient intelligence to apply that knowledge to the case in hand.

From the operative standpoint, it is required to eliminate the point of infection from which organisms and toxic substances are entering the blood, and to prevent further destruction of the bone. This must be done as soon as possible after onset of the disease, and in such a manner that the procedure does not defeat its purpose, by removing further circulation from the bone and thereby adding to the deformity.

The radical operations advised in the past should not be practiced, as simple drainage gives the best result.

STATISTICS OF THIS SERIES

This paper is based upon the study of 138 cases of hæmatogenous osteomyelitis observed in the wards of the Children's Surgical Service, Fourth Division, Bellevue Hospital, during the past six years. All of these patients were under thirteen years of age. Of these 138 cases, the disease was in an acute stage on admission of the patient to the hospital in ninety-eight, and had become chronic in forty. There were eighteen deaths, all in acute cases, a mortality for this type of case of 18 per cent. Of the eighty patients who recovered from the acute stage of their osteomyelitis, seventy-two were followed for periods of a year or longer after their discharge from the hospital in the Return Clinic. Of the forty chronic cases, twenty-six were followed.

Some of these patients were included in the group of seventy-one cases reported in 1925 by Doran and Brown.

FENWICK BEEKMAN.

There were three cases in which the epiphysis was primarily involved; two of the lower femur and one of the lower tibia. There were two cases of Brodie's abscess. Tables showing the apparent cause of death, joint involvement and sequelæ follow.

TABLE I.
Cause of Death.

Case	Sex	Age	Duration of disease before admission	Time in hosp.	Part involved	Cause of death	Blood culture
1. G. B...	F	11 m.	3 wks.	60 d.	Tibia	Pneumonia	
2. P. C...	M	2 yrs.	3 d.	14 d.	Femur	Pneumonia	
3. M. C...	M	2 yrs.	2 d.	2 d.	Tibia	Septicæmia	Positive for staphy. aureus.
4. J. C...	M	17 m.	2 wks.	3 d.	Tibia	Pneumonia	
5. E. D...	M	3 yrs.	3 d.	18 h.	Tibia	Septicæmia	Positive for staphy. aureus.
6. H. F...	M	5 yrs.	1 d.	5 d.	Tibia. Hip-joint	Septicæmia	Positive for staphy. aureus.
7. S. G...	F	3½ m.	2 wks.	12 d.	Humerus	Multiple abscesses	
8. J. K...	M	9 yrs.	3 d.	1 d.	Tibia	Septicæmia	Positive for staphy. aureus.
9. A. H...	M	3½ yrs.	2 d.	4 d.	Humerus	Septicæmia	Positive for staphy. aureus.
10. C. L...	M	8 yrs.	5 d.	1 d.	Humerus	Septicæmia	
11. L. L...	F	8 yrs.	4 d.	2 d.	Femur	Septicæmia	Positive for staphy. aureus.
12. M. L...	M	5 yrs.	3 d.	1 d.	Femur	Septicæmia. Pneumonia	
13. C. L...	F	2 yrs.	1 d.	7 d.	Humerus	Septicæmia	Positive for staphy. aureus.
14. C. N...	M	2 m.	7 wks.	4 h.	Tibia	Not known	
15. C. M...	M	10 yrs.	4 d.	62 d.	Femur	Septicæmia. Suppurative pericarditis. Mult. abscesses	Positive for staphy. hæmolyticus.
16. F. P...	F	9 yrs.	7 d.	30 d.	Humerus	Septicæmia. Suppurative pericarditis	Positive for staphy. hæmolyticus.
17. J. P...	M	6 yrs.	2 d.	30 d.	Tibia. Fibula. Mandible	Chronic sepsis	
18. F. T...	M	9 yrs.	5 d.	3 d.	Tibia	Septicæmia	Positive for staphy. aureus.

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TABLE II.
Suppurative Arthritis from the Primary Bone Involvement.

Case	Age	Joint	Infected from	Remarks
<i>Early from Metaphyseal Lesion.</i>				
1. N. C.....	17 m.	Knee	Femur	Leg now 1½ cm. longer than the other.
2. J. S.....	2½ yrs.	Knee	Femur	
3. A. C.....	1 yr.	Knee	Femur	Leg now 1 cm. longer than the other.
4. J. P.....	8 yrs.	Hip	Femur	Streptococcus.
5. J. C.....	17 m.	Hip	Femur	Died.
6. H. F.....	5 yrs.	Hip	Femur	Died.
7. E. O.....	11 yrs.	Knee	Femur	
8. S. M.....	10 m.	Knee	Femur	
9. J. M.....	9 yrs.	Knee	Femur	Pathological super-condyle fracture of femur.
10. G. P.....	7 yrs.	Shoulder	Humerus	
11. R. P.....	1½ yrs.	Hip	Femur	
12. S. T.....	1 yr.	Knee	Femur	
13. J. W.....	11 yrs.	Elbow	Olecranon ulna	
<i>Early from Primary Epiphyseal Lesion.</i>				
1. A. M.....	10 yrs.	Ankle	Tibia	
2. S. S.....	8 yrs.	Knee	Femur	
3. M. A.....	9 yrs.	Knee	Femur	
<i>Late from Metaphyseal Lesion.</i>				
1. C. R.....	8 yrs.	Knee	Tibia	Epiphysis destroyed—shortening of limb—ankylosis of knee.
2. R. T.....	6 yrs.	Wrist	Radius	
3. C. C.....	5 yrs.	Hip	Femur	Ankylosis.
4. C. L.....	7 yrs.	Knee	Femur	
5. M. M.....	6 yrs.	Knee	Femur	Epiphysis destroyed—shortening of limb.
6. S. O.....	8 yrs.	Hip	Femur	Ankylosis.
7. A. M.....	8 yrs.	Ankle	Fibula	Ankylosis.
8. A. N.....	10 yrs.	Knee	Tibia	

TABLE III.
Sequelæ Following Acute Osteomyelitis.

Type of deformity	Case	Bone involved by osteomyelitis	Remarks
Pathological fracture through metaphysis. (5 cases)	W. K.	Lower femur	Leg now shorter than other.
	T. G.	Lower radius	
	J. M.	Lower femur	
	G. P.	Lower tibia	
	E. F.	Upper tibia	
No regeneration of shaft. (4 cases)	E. W.	Ulna	
	N. S.	Tibia	
	A. D.	Tibia	
	R. Y.	Fibula	
Bowing deformity of shaft. (2 cases)	H. K.	Femur	
	F. C.	Tibia	
Shortening of limb. (4 cases)	W. G.	Upper humerus	Had suppurative arthritis of knee.
	W. K.	Lower femur	
	C. R.	Upper tibia	
	M. M.	Lower femur	
Lengthening of limb. (3 cases)	N. C.	Lower femur	1½ centimetres longer.
	D. M.	Upper tibia	2 centimetres longer.
	A. C.	Lower femur	1 centimetre longer.
Atrophic changes of other parts of limb. (2 cases)	J. S.	Upper femur	Bones of leg and foot well formed but atrophied.
	C. C.	Lower femur	Bones of foot well formed but atrophied.

FENWICK BEEKMAN

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TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

STATED MEETING HELD MARCH 5, 1928

The President, DR. ASTLEY P. C. ASHHURST, in the Chair

CALVIN M. SMYTH, JR., M.D., RECORDER

END RESULTS OF CARPALECTOMY

DR. BENJAMIN FRANKLIN BUZBY read a paper with the above title for which see page 266.

SUPRA-CONDYLOID FRACTURE OF FEMUR

DR. JOHN H. JOPSON presented two patients from his service at the Presbyterian Hospital, illustrating the treatment of supra-condyloid fractures of the femur by skeletal traction. In each case the tongs were used, and traction made through the condyles. Both cases were in young men. In one the fracture was a simple supra-condyloid one. In the second the fracture was of the "T" type, involving the joint, with additional comminution of the major fragments, and in very bad position, including lateral and backward rotation of the separated condyles and vertical displacement. A very satisfactory reduction had been obtained in each case by the use of the tongs. An effort is made in these cases to introduce the tong in each condyle at a point above the axial centre, so that the traction may be combined with forward rotation of the lower fragment from the backward position in which it is held by the hamstring muscles. This mechanism has been emphasized and illustrated by Doctor Blake and by Van De Velde of Belgium. The Thomas splint and Pearson attachment of course are used in connection with the tongs, and after the upper end of the lower fragment or fragments of the femur has been rotated into contact with the shaft, the direction of pull on the tongs is raised to straighten the lower fragment into line with the shaft. Doctor Jopson has consistently found the classical position of the fragments in this type of fracture, and believes it due, as usually stated, to the pull of the gastrocnemii. While perhaps many fracture surgeons practice this method of treatment, in which they personally have great confidence, it is curious that it finds little place in the modern authoritative text-books. An attempt had been made in each of these cases presented, to reduce by the Russell method, in which Doctor Jopson has been interested, but it was apparent after a brief trial that it was not effective in this situation and the tongs were then resorted to, as was his usual practice. After removal of the tongs a split plaster case is applied to prevent displacement before the callus is firm, and physiotherapy begun soon thereafter. Both of these cases were still under treatment, and some limitation of joint motion was still present, but motion was improving.

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DOCTOR JOPSON spoke of other cases previously reported and treated by tongs traction, including one of supra-condyloid fracture complicated by fracture of both bones of the leg on the same side, and one in a child, of anterior displacement of the lower epiphysis of the femur, with fracture of the tibia on that side. Both of these made good recoveries.

DR. WILLIAM O'NEILL SHERMAN, of Pittsburgh, said that the treatment by calipers is the method of choice in this particular type of fracture. Ransohoff of Cincinnati used ice tongs some twenty-five years ago. The Pearson pressure pad can often be used to advantage in conjunction with skeletal traction. It must not be assumed that after the tongs have been applied, that the case can be turned over to the interne. Constant readjustment and supervision is necessary. Open reduction where comminution is present is usually contraindicated. Doctor Jopson failed to state how early walking was begun. One great advantage in the use of tongs, is the ability to mobilize at an early date. Most patients can walk with properly fitting Thomas calipers in nine to ten weeks.

DR. ASTLEY P. C. ASHHURST said that the patients under his own care with supra-condylar fractures of the femur who had been treated by Buck's extension, did not obtain complete reduction of the deformity, and did not always secure complete flexion of the knee after convalescence. However the patients were satisfied and the surgeon who treated them was satisfied.

DR. JOHN H. JOPSON said that concerning Dr. Ashhurst's statement that the patients he treated for this type of fracture by Buck's extension were satisfied with the results; it is possible that the patient had never had the method of treatment outlined by Doctor Jopson on the other leg. The speaker changes his ideas on treatment from year to year. He likes to improve on the methods used. At the present time he has in the ward a woman with a fracture of the shaft of the femur who is being treated by the Russell method. She had been in the speaker's service two years ago for fracture of the other femur. When this fact was brought to his attention, Doctor Jopson asked the patient what treatment she had had on her first admission to which she replied "the British method," but that she liked the present treatment, *i.e.*, the Russell method, better. The British method referred to is the one used by Sir Robert Jones, and consists in the application of Buck's extension and a Thomas splint, and a strapping of the Thomas splint to the frame above the bed and elevating the foot of the bed. Doctor Jopson has used that method successfully in a man who weighed 225 pounds. The speaker thinks if Doctor Ashhurst will give up the Buck's extension and try the tongs extension, he will like it.

As to the length of time which the tongs should be used, the speaker agrees with Doctor Speed that seven weeks is about right. A split plaster case is then applied for two weeks and at the end of nine weeks, this is removed and physiotherapy continued with weight-bearing in eleven to twelve weeks, first with crutches and later without. The use of calipers has not been found necessary.

FRACTURES OF THE OS CALSIS

FRACTURES OF THE OS CALCIS

DR. HENRY P. BROWN, JR., and DR. A. A. WALKLING (by invitation) presented slides, showing results in cases of fracture of the os calcis which they had followed. These cases were from the services of Dr. Charles F. Mitchell and Dr. John H. Gibbon at the Pennsylvania Hospital. The reporters were of the opinion that the results in the treatment of fractures of the os calcis do not compare favorably with those attained in the treatment of other



FIG. 1A.—Shows typical fissure fracture of os calcis before treatment.

fractures, and that the importance of their management is not realized by surgeons in general.

Fractures of the os calcis comprise 2 per cent. of all fractures. In the seventy-one cases reviewed, 92 per cent. occurred in males whose average age was forty-one, the youngest nine and the oldest eighty. Fifty per cent. occurred between the ages of thirty and fifty. The treatment of these fractures, some dating back as far as 1910, was a plaster case for varying lengths of time, in positions which varied with the type of fracture. The patient went about on crutches and then with a cane for varying periods. Some of these patients still require a cane and are unable to work. The disability ranges from none in certain types to complete in others. It seems that in the avulsion type, expectant treatment is all that is necessary. If there is spur formation with pain, the spur should be removed. The disability here is slight. The types with flattening, shortening or involvement of the subastragalar joint need surgery in some form. Whether it be (1) moulding, (2) excision of callus and remodeling, (3) subastragalar arthrodesis or (4) any combination of these three procedures; depends they think on the type of fracture and disability.

All of their cases, except the avulsion fracture, complained of painful lateral motion, especially eversion. There was marked widening of the os

calcis with excess callus beneath the malleoli, especially the external. There was usually a flat foot. The severely comminuted fracture, with many fracture lines entering the subastragalar joint, might probably do better with moulding combined with subastragalar arthrodesis. The fissured type which involves the subastragalar joint can also be treated in this way.

It seems that the application of tongs or hooks to bring fragments down



FIG. 1B.—Shows same case after treatment. Subastragalar joint fairly clear. Functional result poor.

is not a good thing. An infection occurring in this already badly contused tissue is apt to be very troublesome. Osteomyelitis of the os calcis is usually quite a serious matter and prolongs hospitalization.

DR. FRASER B. GURD, of Montreal, said that in all such cases in which it was thought that improvement in the position of the fragments might be obtained, the foot has been hammered into position; the foot is first placed in a pillow splint and the hammering is done on the fifth, sixth or seventh day, never earlier than the fifth day. A full boot of plaster is made with the foot at about a right angle with the ankle-joint and in as marked abduction as can reasonably be secured. The first plaster is applied over a small amount of cotton. The foot of the bed is raised for ten days; then the plaster is removed

FRACTURES OF THE OS CALSIS

and a second plaster is put on, this time without padding and fitted closely to the upper part of the leg. The patient is urged to walk, if possible without crutches or a stick. Those with a single fracture seem able to walk without a stick or crutch, but the bilateral cases must have crutches as they are not stable.

The patient is allowed to remain in and urged to walk in the plaster or plasters during the ensuing two and one-half to three and one-half months,



FIG. 2A.—Shows comminuted fracture of os calcis.

the plaster being changed as required owing to the wear and tear causing it to break through. If the hospital facilities permit, Doctor Gurd prefers that the patient should be readmitted for the change of the plaster and for two or three days physiotherapy at the same time. At the end of three or four months the plaster is removed and both sole and heel of the shoe are tilted, raising the inner border one-half inch, and sometimes as much as three-quarters of an inch—so that the patient walks on the lateral border of the foot. During the next two and a half months, the amount of tilt is gradually reduced so that in eight months time, he is walking with one-quarter inch tilt only and is as a rule able at the end of eight or nine months to go back to his work. The patient is advised to continue to wear one-quarter inch tilt for the remainder of his life.

DR. NATHANIEL ALLISON, of Boston, said that he did not wish the gentlemen present to think that they have heard the ultimate conclusion in regard to the treatment of fractures of the os calcis, as outlined by Doctor Gurd. Tonight Doctor Gurd used the term "as a rule"; this afternoon, he told us 80 per cent. of his cases returned to work. The feeling in Boston is that this is not the best treatment for fracture of the os calcis. After having been through all these various methods of treatment, including plaster and hammering, although perhaps not through the tilting of the shoe, Doctor Allison believes that these patients have pain because they injure tremendously the

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subastragalar joint and that is why they have disability. The thing to do for them is to destroy the subastragalar joint and unite the astragalus and os calcis and hence do away with the pain. Of twenty-five cases treated by this method, in only three have good results not been obtained, and in much less time than required by the method described by Doctor Gurd.

DR. FREDERICK COTTON, of Boston, said that they had heard what hap-



FIG. 2B.—Shows treatment. Subastragalar joint quite clouded. Function poor. Arthrodesis probably needed for cure.

pens without remodeling treatment on a conservative basis; it does not work. With skill and attention one can remodel these cases and the speaker has had results with the method described by Doctor Gurd, which were very satisfactory. There is a place for conservatism in the use of mechanical treatment. Since Doctor Wilson brought out his method of subastragalar arthrodesis, Doctor Cotton has used it—not in the new cases but in the ones which have not done well by other methods.

DR. CLAY RAY MURRAY, of New York, said that he pursues the method of subastragalar arthrodesis very infrequently, reserving it only for those cases in which there has been marked bone deformity. In the majority of cases, he tries to mould the bone back into the original form, as Doctor Cotton has suggested, then to immobilize it in plaster for six to eight weeks with marked inversion of the foot, tilting the foot to the inner side, and following this by

FRACTURES OF THE OS CALSIS

weight-bearing with the insertion under the heel of an ordinary rubber bath sponge with the idea that by this method one eliminates from the weight-bearing the sudden pounding-down on the heel by giving an elastic pad under the heel.

DR. PHILIP DUNCAN WILSON, of Boston, pointed out that examination of these cases showed that the pain of which they complained was usually a pain felt when they walked on an uneven surface, that anything which caused lateral motion of the foot caused pain. Examination of such a foot showed good ankle motion, but deformity of the heel and limitation of motion in the lateral plane when an attempt was made to invert the foot. The motion was not all gone because there was pain when we attempted to invert; if it had been entirely ankylosed, there would have been no pain. There are other causes of trouble—the possibility of having the foot fixed in inversion—deformity on attempting to throw the heel out—this means that the weight of the body deviates more to the inner side and there is more tendency to turn the foot over. Certain cases have trouble from irregularity of the surface of the plantar bone; but the chief factor is the presence of pain on lateral motion which can be demonstrated by examination and which should be “run to earth”. X-rays have shown it to be a traumatic arthritis of the subastragalar joint, a traumatic arthritis which is evidenced by the fact that there is great tendency to lipping about the joint and thinning of the joint cartilage. That is the reason for doing a subastragalar arthrodesis. As to Doctor Gurd’s method of treatment, the speaker cannot see anything in it which changes the basic factors with which one is dealing. He does not reduce the deformity any more than had previously been done; he only fixes the foot for a little longer period of time, and allows the patient to weight-bear instead of staying in bed. This method will not change the basic condition in these feet. Good results may be due to the fact that under the weight-bearing influence he tends to stimulate ankylosis of the joint. When the X-ray shows severe comminution of the os calcis with involvement of the subastragalar joint and irregularity of the joint surface, it is fair to assume that these patients are going to have pain indefinitely until the joint is returned to the original position or until the joint motion is eliminated.

DR. KELLOGG SPEED, of Chicago, called attention to the lack of unanimity concerning treatment of fractures of the os calcis. One enthusiast cuts down on the bone and by narrowing it, takes away the pressure from the external malleolus caused by its thickening. Most men, however, treat these fractures by means of prolonged immobilization with the foot in adduction. Subastragalar arthrodesis is being accepted as the last word in the treatment of the painful feet with prolonged disability in those cases which require compensation adjustment.

DR. FRASER B. GURD, said that a large proportion of these cases of severe fracture show no movement between the os calcis and the astragalus. Doctor Gurd took exception to Doctor Wilson’s statement that the treatment described by the speaker accomplished nothing more than the older methods. His feel-

ing is that the prolonged walking, following the removal of the plaster and the external tilted position, are of a very great deal of importance in preventing strain of the subastragalar joint. His patients cannot as a rule, abduct the heel; the foot is forever in the position of adduction. It is not the adduction but the abduction which causes pain on walking on irregular surfaces. As the patient cannot abduct, he cannot suffer the pain. *Pari passu* with the continuance of the adduction of the heel there is a tendency for any new bone which may have developed in the neighborhood of the peroneal tuberosity to absorb on account of its freedom from irritation.

COMPOUND FRACTURE OF TIBIA AND FIBULA WITH NON-UNION

DR. EDWARD T. CROSSAN presented a specimen consisting of the lower two-thirds of the tibia and fibula, with the foot attached. The patient, a man, age twenty-eight years, was originally admitted in October, 1924, to the Episcopal Hospital, in Doctor Ashhurst's service, for fractures of both legs, that of the left being badly comminuted, and with a large wound of the soft parts. The right leg united without deformity, but the fracture of the left tibia remained ununited, one of the large fragments having been removed as a sequestrum before final closure of the wound, which occurred about a year after the injury. The patient wore a brace and walked with crutches for more than three years, when he returned to the hospital (in January, 1928) with evidence of infection at the site of the non-union, the soft parts having been firmly healed for more than two years. Doctor Crossan opened the abscess, finding the ends of the tibia carious; and, at the earnest solicitation of the patient, amputated the leg in February, 1928.

To secure union in the tibia, it would have been necessary to wait until the wound became aseptic, and then insert a bone-transplant. The patient was opposed to any such long delay, and preferred an artificial leg.

The specimen, of which shows bony union of the fibula, without deformity; the site of the second fracture in the fibula can no longer be recognized. The tibia is entirely ununited, its ends showing proliferative and inflammatory changes, with a gap of 1.5 to 2 cm. between them. A steel pin had been passed through the calcaneum, and used for traction for a period of about three weeks at the time of the original injury; the röntgenogram shows this tunnel apparently still open, but in the specimen the outer end of the tunnel is closed, but the medial end is widely open. The incisions in the soft parts had not become infected and had remained healed ever since the removal of the pin.

FRACTURES OF FEMORAL NECK TREATED BY THE WHITMAN METHOD

DR. DAMON B. PFEIFFER related briefly the histories and showed X-ray plates of several cases to serve as a text for remarks concerning the utility of the Whitman abduction treatment for fractures of the neck and trochanteric region of the femur.

One of these cases was unusual in that a woman of eighty having recov-

FRACTURES OF FEMORAL NECK

ered from a fracture of the neck of the femur treated by Whitman's method, fell six months later and sustained an identical fracture on the opposite side. She was again treated in the same manner and good union was secured. It is noteworthy that in this case immediately prior to her first fall her death had been expected almost momentarily owing to the condition of her heart, which was dilated and fibrillating. For the first few days after the accident decompensation was extreme and but slight hope was entertained of recovery. She rallied sufficiently, however, in ten days to permit the application of the case with a few whiffs of ether in order to obtain abduction. Gradually the cardiac condition improved until the heart action became entirely regular and remained so until a fatal attack of cholecystitis five months after the second fracture. It is not too much to say that the immobilization following the fracture saved her life. It is a striking refutation to the idea formerly held that it is unwise to place these aged individuals in a plaster case for fear of circulatory depression. It is an apparent paradox that immobilization of the fracture by these massive cases actually mobilizes the patient, permitting a considerable variety of positions to be achieved by ingenious nursing care. Elevation of the head of the bed, the lateral and the prone positions should be alternated with the dorsal position. These changes, in addition to preventing pressure sores, act as stimulants to the circulation. A suggestive recommendation of this method, as against the older plan of treatment by some form of Buck's extension is to be found in the fact that nurses who have cared for patients under both methods greatly prefer the case, since it makes the patient more comfortable and the nurse's work easier. Of fifteen patients treated in this manner in the last five years there was one death which occurred in a greatly debilitated and arthritic woman over eighty years of age as a result of senile gangrene of the affected extremity. It is not believed that the case was responsible for the gangrene, as this patient was treated for several days without the case on account of her rheumatic contractures and was placed in the case only because of her continued complaint of pain in the leg which in retrospect was apparently due to senile circulatory disturbances, though this was not recognized until after the case had been applied. Functional results have been excellent in about 85 per cent. of the cases and good in the remainder.

During this time only one fracture of the hip has been treated without the case. This was a very stout woman of eighty-six years of age with a firmly impacted fracture at the base. The patient eventually recovered and at the present time, two years later, is able to walk with assistance.

It is the reporter's feeling that there are few exceptions to the rule that fractures in this location should be treated in the manner so clearly described by Whitman.

DR. CALVIN M. SMYTH, JR., said that he employed the Whitman case in all fractures at the hip including those fractures which were already impacted and in satisfactory position when first seen. In the speaker's experience such patients are much easier to nurse and are more comfortable even though the fracture, in itself, may not require immobilization in abduction. The frequent

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change of position, which the case allows is a distinct advantage to the patient with impaired circulation. The Whitman case has been employed in two such cases recently with great satisfaction on the part of the patients, the nurses and the surgeon.

TREATMENT OF FRACTURES INVOLVING THE ANKLE-JOINT

DR. FRASER B. GURD, of Montreal, by invitation, read a paper with the above title for which see page 260.

UNHAPPY RESULTS IN TREATMENT OF FRACTURES

DR. KELLOGG SPEED, of Chicago, spoke on the above topic, using lantern slides to illustrate his remarks. The unhappy results mentioned by him were: 1. Loss of length of legs. 2. Angular deformity, unsightly and disabling. 3. Delayed or non-union. 4. Infection; osteomyelitis; loss of limb. 5. Involvement of blood-vessels, nerves, tendons or muscles causing functional loss. Volkman's paralysis. 6. Disability in joints. 7. Neurasthenical states.

Means of Avoiding Unhappy Results.—1. Divide all fractures into those of the shaft or those near the joint. Their underlying treatment is essentially different. Fracture near a joint requires immediate setting, whereas a great many fractures of the shaft require traction and prolonged extension or even operation.

2. Inspect and record findings in writing concerning nerves, blood-vessels or muscle injuries. When primary injuries are present, operate at once (in 80 per cent. at least).

3. Minimize chance of infection:

(a) By proper protection of the parts even in closed fracture. Every fracture of the leg, the limb should be washed and the skin cleansed with alcohol or some mild antiseptic. (b) Immediate primary operation in all open fractures. (c) Greater attention to closed methods, thereby reducing the ratio of operative treatment.

4. Immediate (permanent) treatment. Immediate treatment should merge always into permanent treatment; it should not be given haphazardly: (a) Reduce joint fractures completely; and control this by röntgenogram. (b) Put shaft fractures in position and splint or use extension traction. (c) Check position of fragments by the röntgenogram and if it is unsatisfactory, use skeletal traction.

5. Early active motion and massage even in the splint. Do not immobilize too long. Avoid early weight-bearing or work which might cause secondary deformity. Do not let the patient walk too soon on soft callus or use too soon a joint which may be pressed into secondary deformity. Active motion and the galvanic current for muscles.

6. Increase the blood calcium when delayed union is feared.

Sacrifice length of limb if necessary for irritation of the bone ends, as by the use of walking calipers or splints to promote bony union. Lantern slides of cases were shown illustrating various fracture conditions.

TRANSACTIONS OF THE NEW YORK SURGICAL SOCIETY

STATED MEETING HELD MARCH 14, 1928

The President, DR. FRANK S. MATHEWS, in the Chair

ENDOTHELIAL MYELOMA OF THE FEMUR

DR. ROBERT H. KENNEDY presented a girl fourteen years of age, who was first seen by him February 16, 1927, complaining of pain in the left thigh. Family history negative for cancer. Patient never had any serious illnesses. There was an indefinite history of being kicked on this thigh several years previously. The present illness dated back about two years, the only complaint being intermittent pain in the thigh, becoming steadily more frequent and more severe. Over one year before the pain was so severe that a physician was called. During the previous three months the girl had remained in bed for a day several times on account of the severity of the pain. She had been gaining in weight, but slowly for her age.

Physical examination was negative except for the left thigh. This was 1 cm. smaller than the right at various levels. No swelling. No vessels evident. On palpation the femur felt diffusely enlarged in its middle third and was tender. The soft parts seemed movable over the bone. No lymph-nodes were felt. The radiograph showed a rarefaction of the bone from the lesser trochanter to the junction of the middle and lower thirds of the shaft, most marked for about four inches in the middle, with considerable swelling of the shaft at this point. The cortex did not appear to be definitely broken through at any point.

The patient was admitted to the Beekman Street Hospital where an exploratory osteotomy was done four days later. Red blood cells 4,200,000, hemoglobin 85 per cent., white blood cells 8,800, polymorphonuclears 71 per cent. Wassermann negative. Six urinalyses were negative and no Bence-Jones proteins were found. Radiograph of chest negative for lung involvement. Through an incision on the outer aspect of the thigh it was found that the soft parts were not involved. The periosteum separated readily from the bone, which was slightly roughened and porous. Cortex was thin, and a smooth, soft, vascular mass bulged into the opening as soon as the cortex was removed. After removing specimen the opening was cauterized to stop bleeding and the wound closed. It healed by primary union.

Microscopical examination of sections show for the most part, round or oval spaces (endothelial spaces?), a number of which are empty but most of which are filled with fairly large, round or oval cells with light vesicular cytoplasm and round anaplastic, somewhat irregular-sized and shaped, deeply staining blue nuclei. The cytoplasm of many of the cells and areas where the cells no longer retain their identity, appear to be the site of a myxomatous change. A moderate amount of interstitium is present, much of which is myxomatous.

Pathological diagnosis.—Primary endothelioma of bone. (Ewing tumor.)

Further operation was not considered advisable because—

(1) The nature of the lesion. If this was an Ewing's tumor, they are usually multiple early. The only other probability seemed to be a metastasis.

(2) The duration of the lesion. With symptoms dating back at least two years it seemed unlikely that there was not some other lesion in the body which had not been demonstrated.

(3) The extent of the lesion. With involvement up to the lesser trochanter, a disarticulation at the hip-joint would have been necessary and taking (1) and (2) into consideration this did not seem worthwhile. She was, therefore, fitted with a Thomas walking caliper splint to guard against fracture of the femur and returned to school.

She was subjected to X-ray treatment by Dr. Raymond Lewis. An attempt was made to keep the tissues saturated with radiation over a considerable period. To do this following was given:

March 12, 1927 and March 26, 1927 somewhat over a full suberythema dose was given, using anterior and posterior portals. April 19 and April 23, half a dose. May 27 and June 11, half a dose. July 9 and July 18, two-thirds of a dose. September 28 and October 6, two-thirds of a dose.

A temporary epilation was produced, but no other skin changes.

Coley's serum was given steadily up to a dosage of 7 minims. The patient was free from pain while in bed and after commencing to use the splint. She gained in weight from 99 to 114½ including the splint. Radiographs taken at intervals appeared to show some increase in diameter of the bone, but also there appeared to be more calcium laid down within. She got about well with her splint, even riding a bicycle.

This case was registered with the Committee on Bone Sarcoma as No. 801 and the sections reported on by various pathologists. Their opinions were about equally divided between Ewing's tumor and a metastatic tumor.

The girl was again admitted to Beekman Street Hospital, December 10, 1927, having tripped on a rug the day before, fallen forward and struck the left knee lightly. This was followed by immediate pain and swelling. The extremity was put up in adhesive plaster traction suspension. The radiograph showed a severely comminuted fracture of the left femur involving the shaft for about three inches. Radiograph of lung was still negative and no lesions made out in other bones or in abdomen. Disarticulation at the hip-joint was therefore advised so that the patient might not be confined to bed.

The patient's blood was grouped for transfusion by two technicians as group IV. Eight possible donors of this group were cross matched but agglutination of the patient's cells occurred with all. The idea of a post-operative transfusion was therefore abandoned. Red blood cells 4,000,000, hæmoglobin 80.

Operation.—December 23, 1927 under 0.10 gm. neocaine spinal anaesthesia a disarticulation was done at the left hip-joint. The common femoral artery and vein were first tied immediately below Poupart's ligament. Wyeth's pins were then passed and a tourniquet placed above these. An external racquet incision was used. No involvement of the soft parts was seen. A cigarette drain was inserted to the acetabulum and another under the distal portion of the stump. Patient lost almost no blood but was in moderate shock, which was believed to be partly due to the rather large dosage of spinal anaesthesia for her weight. Her condition improved markedly following an intravenous infusion of 750 c.c. normal saline.

The patient had a post-operative reaction up to 102.6, twelve hours later, but made a good recovery, being discharged on the twenty-first day walking with crutches. The wound healed by primary union except for the drain site.

Microscopical report same as at the biopsy. Her weight was seventy-five pounds on discharge from the hospital and when last seen, February 27, she weighed ninety pounds. He had been unable to make out any other lesions.

SUPPURATIVE CHONDRITIS OF CHEST WALL

DR. CHARLES G. DARLINGTON remarked that the greatest part of the existent confusion on the entire subject of bone tumors is largely due to terminology. An exceedingly large number of different names have been given to various tumors, many of which are actually the same tumor, causing a confusion which can be largely remedied if one but follow the classification of the Bone Sarcoma Registry. It must be admitted that confusing terminology is not the only cause of misunderstanding, on this subject, as there still is a world of knowledge, as yet unknown, which will have to be gained before confusion will no longer exist.

The essential features of the tumor reported by Doctor Kennedy are: A primary malignant bone tumor showing characteristic cells, involving the shaft of a long bone, arising in the medulla, comparatively slow growth, growing diffusely, in early stages clinically and röntgenologically resembling osteomyelitis, responding to radiation temporarily, usually found in younger subjects and with a poor prognosis.

Opinions may differ as to whether the lesion is a secondary or a primary one. In favor of it being secondary it is to be noted that

1. The alveolar arrangement might suggest an epithelial origin.
2. This arrangement, with the type of cell with its swollen clear appearance and the peculiar appearance and arrangement of the stroma, might suggest hypernephroma.

Against it being secondary but in favor of it being primary, the later sections after the amputation are much more typical than when the biopsy sections were submitted. From these it is to be noted that

1. The appearance of the cell, endothelial (?), the nuclei of which are different from those of the hypernephroma cell, and the swollen clear appearance of the cell which in the biopsy slides were thought to contain mucin rather than fat.
2. The peculiar arrangement of the stroma which would correspond with the stroma of bone marrow.
- Further but not last in importance: 3. The age of the patient.
4. The diffuse location in the medulla of the shaft, and
5. The observation of the patient for over two years with no symptoms of a primary tumor or a secondary growth.

As to the ultimate outcome of these cases a definite specific answer is impossible, however temporarily they seem to be favorably influenced by radiation but the general expectancy of life is slightly longer than that in osteogenic sarcoma, which is to quote Kolodny three years as compared with twenty months.

Doctors Ewing, McGuire and McWhorter, and the Registry all cite the same case where radiation, Coley's toxins and amputation were used, in which the patient was well without evidences of recurrence sixteen years after operation. This case however was an adult. There are other cases on record living and well after four years.

SUPPURATIVE CHONDRITIS OF CHEST WALL

DR. ROBERT H. KENNEDY presented a young girl, who was first seen by him in May, 1925, because of a painful swelling of the lower anterior chest

wall mesial to the right breast. This had been first noticed ten days previously. There was an indefinite recollection of striking against a chair several weeks before. Her past history was irrelevant, except for two severe attacks of pneumonia, the second one six months previously. General health at this time excellent.

The swelling was about 3 cm. in diameter, tender, not red nor hot. Skin free over it, but felt attached to deeper parts. Radiograph failed to show any lesion of the chest wall or the lungs. A large number of calcified mediastinal nodes were present. Two weeks later the area was much smaller and less tender.

About two months after the onset, the skin became inflamed and two pinpoint openings had appeared, discharging pus. When again seen by the reporter there was an opening, about 1.5 cm. across, with ragged bluish edge, filled with exuberant granulations. These were cut away and the pathologist reported granulation tissue. Bare cartilage could be felt with a probe. Radiographs failed to show involvement of costal cartilage or bone. Bismuth injection showed a sinus about 2 cm. deep. For the next two months the wound was cleaned and various dressings used until there seemed to be a sequestrum.

October 10, 1925, under local anæsthesia, the tract was excised and the sixth costal cartilage was found involved at the chondro-sternal joint, with the inflammation extending to the adjacent joint above and below. These were rongeuired and curetted away, leaving an opening about 3 cm. in diameter, lined by apparently normal cartilage and sternum. The discharge continued as before, cleanliness and various antiseptics, chiefly the chlorines, being used for dressings.

Two months after operation the patient was seen in consultation with Dr. Walton Martin, who advised conservative treatment with carbolic acid and the quartz light. For two months three times a week the wound was scrubbed carefully and carbolic acid was applied. The discharge was somewhat less, granulations not exuberant and bare cartilage in the base of the wound. She received quartz light therapy three times a week during this period. All applications were then stopped, the wound being simply wiped out gently. The quartz light was continued and in one month the wound was healed. Quartz light was continued for three weeks longer.

The wound has now remained healed for two years and she has had no symptoms referable to this region.

DR. ALEXIS V. MOSCHCOWITZ stated that in 1918, in a paper read before the American Surgical Association, he reported a number of cases of suppurative chondritis of infectious nature, and none of these healed until the entire cartilage was removed into osseous tissue.

Only recently, he had occasion to treat a case of typhoid chondritis which had been operated upon a number of times and always healed down to a sinus. The final operation was very extensive, inasmuch as the sixth, seventh, eighth and ninth costal cartilage including the xiphoid appendix had to be removed on both sides. After this, the patient made a prompt and complete recovery.

PEDICLE GRAFT OF KNEE FOLLOWING SYMPATHECTOMY

DR. RALPH COLP presented a boy, twelve years of age, who was admitted to the Beekman Street Hospital, October 23, 1926.

The boy was first admitted to the hospital, September 29, 1925. Four years previous to admission while riding on a moving elevator, his left knee

TUBERCULOUS ULCER OF THE STOMACH

was caught against the wall, and the skin avulsed. At this time he was treated by skin graft, but the wound failed to heal and he was discharged with a persistent prepatellar ulcer.

On his first admission to the hospital, he had a chronic ulcer, surrounded by scar tissue extending over the anterior surface of the knee, both above and below the ulcer for several inches. Under gas and oxygen anaesthesia, the fibrous scar tissue about the wound covering the patella was excised, and with a small drill, six holes were made in the anterior surface of the patella to promote granulations. Parassine dressings were applied. In two weeks' time, the granulations appeared healthy enough to graft but the pinch grafts which were applied did not take. At this time a pedicle graft was suggested, but the patient left the hospital against advice.

Finally, on October 23, 1926, the patient was readmitted for the pedicle graft. The local condition at the time was practically the same.

November 6, 1926, the scar tissue over the patella was removed and several drill holes were again made into the patella. However, after three weeks' time, the granulations were still sluggish, pale and dry, with a sloughing tendency.

November 29, 1926, a Leriche operation was performed in the hope that a periarterial sympathectomy might sterilize the wound. A $3\frac{1}{2}$ -inch incision was made over the femoral vessels, the artery was isolated and its adventitia stripped from Poupart's ligament to the profunda femoris. During this procedure, the vessel did not change in diameter, and no gross change was noted in the color or circulation of the foot.

Within twenty-four hours, however, the granulations appeared healthier, although no other circulatory changes were noted, and within five days the granulations had so improved that a pedicle graft which was formerly impossible, was now practicable.

December 6, 1926, a pedicle graft to the right knee was made by raising a flap from the posterior surface of the right calf, the denuded area being covered with Thiersch grafts. Both legs were encased in a plaster spica.

Two weeks later, the pedicle was severed. The graft was almost completely viable and the Thiersch grafts to the calf had all taken.

January 13, 1927, the patient was discharged with the wound of the knee completely healed except at its upper margin, where there had been a slight skin necrosis.

At present the knee is completely healed, motion is complete, and the patient has been attending school regularly, engaging in ordinary athletic sports. The grafted area on the posterior aspect of right leg looks well and the contour of leg is practically normal.

Leriche, a few years ago, called attention to the fact that following periarterial sympathectomy, chronic ulcerations and slowly granulating wounds often healed unusually rapidly. This case was apparently aided in a dramatic fashion by the femoral sympathectomy. While there is no laboratory proof of the sterilizing value of this procedure in this particular case, clinically a sloughing wound was transformed into one which became clean enough to successfully permit a pedicle graft.

TUBERCULOUS ULCER OF THE STOMACH

DR. RALPH COLP presented a negro, fifty-six years of age, who was admitted to the Beekman Street Hospital, February 25, 1927.

In 1921, following an attack of pneumonia, the patient vomited a great deal of dark brown material, streaked with bright red blood, and at the same time he noticed that his stools were tarry. He has not vomited since but has

had yearly attacks of tarry stools lasting four to five days. His last attack began two days prior to admission when he vomited dark brown material and noticed his stools were again tarry. At no time had there been any epigastric pain or distress, or gaseous eructations. His appetite has been fairly good and he has not suffered any recent loss of weight, although at present he feels quite weak.

The past history is negative. He was a rather well developed, poorly nourished, elderly negro, not acutely ill. There was definite evidence of a healed lesion at both lung apices, but no signs of either active or healed pulmonary tuberculosis elsewhere. The abdomen presented no signs except slight abdominal distention.

X-ray examination of the gastrointestinal tract showed a penetrating ulcer of the lesser curvature of the stomach and a definite and persistent deformity of the first portion of the duodenum, which was regarded as diagnostic of ulcer. The stomach, duodenum and most of the jejunum were empty in six hours. Röntgenographs of the chest shows evidence of old healed apical tuberculosis.

The Wassermann examination was negative. The blood count showed 4,200,000 red blood corpuscles, with a hæmoglobin of 72 per cent., and 12,000 white blood cells with 76 per cent. of polymorphonuclear leucocytes.

Examination of the urine revealed no abnormality.

Gastric analysis of the fasting content showed free hydrochloric acid, 40. Total, 64. A Refus test-meal: 1st half hour free hydrochloric acid 68. Total 89; 2nd half hour free hydrochloric acid 84. Total 103; 3rd half hour free hydrochloric acid 100. Total 115, with epithelial cells and blood. The sputum at all times was negative for tubercle bacilli.

Feeling that the case was one of gastric and duodenal ulcer, the patient was explored, the operation being started under field block and concluded under gas and oxygen anaesthesia.

About 1½ inches from the cardiac orifice, on the lesser curvature of the stomach, was a hard, indurated ulcer which measured about 1 inch in diameter. The ulcer appeared punched out with overhanging edges. The serosa was thickened in this region and surmounted by three enlarged partially suppurating closely adherent lymph-nodes. The remainder of the stomach was normal except for a scar on the anterior aspect of the first portion of the duodenum, evidently an old ulcer. A typical sub-total gastrectomy was performed closing the stomach and performing a posterior button gastro-enterostomy. The abdomen was closed without drainage.

The pathologist's report disclosed a tuberculous ulcer of the cardiac end of the stomach, with an active tubercular lymphadenitis.

The patient did fairly well following operation with the exception that two weeks later, he developed pain in the left thorax with a friction rub, which was soon followed by an effusion. Aspiration of the chest yielded 23 ounces of straw-colored fluid which contained tubercle bacilli. Examination of the lungs, however, clinically and by X-ray, showed no activity at any time.

Since his operation, he has gained forty pounds in weight and has had no recurrence of his gastric symptoms, nor any signs of active tuberculosis elsewhere.

This case is presented as a probable case of solitary tuberculous ulcer of the cardiac region of the stomach. According to Broder's grouping in his paper in the November, 1917, issue of *Surgery, Gynecology and Obstetrics*, it cannot be classified as a positive case because attempts to find the tubercle

EXCISION OF SUBMAXILLARY GLAND

bacilli have been unsuccessful although the histological picture both of the ulcer and the lymph-nodes are quite characteristic of tuberculosis. It is interesting to speculate on the etiology in this case. It conforms partially to the cases of Clayton and Williamson and Chiari reported by Broder in which the tuberculosis was primary in the lymph-nodes at the hilus of the lung, and the retrogastric lymph glands and the stomach were infected secondarily by a blockage of the lymph vessels. In this case before the gastric artery could be ligated proximal to the lesion, the three adherent lymph-nodes had to be sharply dissected away from the base of the ulcer. It appears more than likely that the gastric ulcer was secondary to the tuberculosis of the nodes.

DR. CHARLES G. DARLINGTON said that the diagnosis of tuberculosis in this case was made on the

1. Histopathologic picture of typical epithelioid tubercles, with caseation and giant-cell formation in the submucosa of the stomach beneath the ulcer, and other evidences of tuberculosis such as the typical gross and microscopic tuberculous picture of the lymph-nodes attached to the lesser curvature of the stomach at a point in the wall directly corresponding with the ulcer and
2. The absence of any features of syphilis.

He was unable to demonstrate the tubercle bacilli in smears or tissue from the stomach or lymph-nodes and while guinea pig inoculations were not made, and the diagnosis was made on the features already mentioned, the subsequent development, by the patient, of a tuberculous effusion in the chest in which tubercle bacilli were demonstrated is strikingly confirmatory evidence.

EXCISION OF SUBMAXILLARY GLAND FOR INFECTION OF THE FLOOR OF THE MOUTH

DR. RALPH COLP presented a man, age twenty-seven, who was admitted to the Beekman Street Hospital, June 21, 1927.

Eight days prior to admission, the patient was struck on the right side of the jaw with a baseball bat, causing a fracture of the mandible. He was taken to a hospital, but left the following day. Twenty-four hours after admission his face became so swollen that he could not open the right eye. About the same time he experienced great difficulty in deglutition. When admitted he was acutely ill but fairly well nourished and developed. Cyanosis was marked and the respirations were labored, obstructed and increased in rate. There was a pronounced swelling in the right side of the face. The eye was closed. The right submaxillary region and practically the entire side of the neck was brawny, hard, and œdematous, but not red nor warm. The temperature was 103, and the pulse 120. It was impossible to open the mouth more than about one-half inch, but the tongue was seen to be elevated. The mucous membrane of the floor of the mouth was œdematous. There was marked tenderness at about the middle of the ramus of the right mandible, bony crepitus and malalignment of the teeth. A deep infection of the floor of the mouth was evident. Under local anæsthesia, a five-inch incision, 2 cm. below and parallel to the ramus of the jaw was made which was deepened by blunt and sharp dissection, and the submaxillary salivary gland was exposed and extirpated. On section, it was normal. No pus was

encountered until the gland was dissected from its retromaxillary recess. Rubber dam drains and packing were inserted into the retromandibular and mylohyoid spaces.

The patient showed almost immediate improvement after the operation, and within twelve hours was able to swallow with greater ease and open his mouth about one inch. After five days, the packing was removed and the wound irrigated twice a day. Two weeks after operation, he was discharged with a granulating neck wound and referred to a dentist for wiring of the teeth.

The reporter added that in previous communications, the removal of the submaxillary gland has been advocated in deep infections of the submaxillary triangle and in phlegmonous infections of the floor of the mouth. This procedure is not based upon the pathological involvement of the salivary gland for this occurs in less than 50 per cent. of the cases, but it is done simply to promote drainage of the retromandibular submaxillary and mylohyoid triangles through the removal of the gland. In this case following a fracture of the mandible, the infection was deep to the salivary gland and drainage was only possible after the gland was removed. A medium suprahyoid incision in this instance would have been without avail.

DR. JOHN M. HANFORD questioned the necessity of an incision into the neck in any such abscess so closely beneath the mucous membrane of the floor of the mouth. If this condition was a subperiosteal abscess deeply located beneath the submaxillary salivary gland might not drainage have been established by an incision within the mouth? It was true that not all cases could be so drained. Assuming that there be an abscess deeply located in the submaxillary space, or in its floor, if the gland could so readily be removed, so might it be readily pushed aside by gentle anatomical dissection along tissue planes with maintenance of drainage. This would obviate the necessity for the more extensive dissection in the presence of virulent infection.

DR. JOHN A. MCCREERY said that he had seen a considerable number of these cases treated both by excision of the gland and by drainage. He had been impressed by the smoother and more rapid convalescence in the cases in which the gland had been removed, as in those treated by drainage alone the sinus had frequently closed too early and had had to be reopened. There had been occasional objection to the removal of the gland on the ground that this was followed by dryness in the mouth. He had had occasion to see a number of these cases in the follow-up clinic and none of the patients had complained of this condition. He felt very strongly that the removal of the submaxillary gland was by far the most satisfactory method of treatment of this exceedingly serious condition.

PARASINOMA OF THE KNEE

DR. JAMES N. WORCESTER presented a man, twenty-seven years of age, who was admitted to Beekman Street Hospital in June, 1927. In 1917, while in the Italian army this man had suffered from "trench rheumatism". At a hospital back of the lines something was injected into knee. This was some kind of oil. Following this he has had a lump on the front of knee which gave

CONSIDERATIONS IN SURGICAL DISEASE OF THE BILIARY TRACT

no trouble until a month ago when he fell on his knee and an ulcer developed.

When admitted there was over the anterior surface of the left patella a mass, 2 x 3 inches, projecting above the level of the skin for a distance of one inch. This is reddish-purple in color and in the centre is a deep ulcer with sharp, clean-cut edges. Motion of the knee is practically normal.

This mass is sharply defined and feels like cartilage. Can be slightly moved on patella. Not tender. Wassermann negative.

June 20, 1927, the mass was excised and the skin edges anchored with heavy silk. Twenty-five days later a flap graft from the other calf was done by Doctor Mage. The raw area covered by Thiersch grafts. Pedicle cut ten days later. Later a few Thiersch grafts applied. Patient went home two months later.

Diagnosis: Chronic inflammation about foreign material. Ulceration.

FRACTURE OF FOREARM AND OF BONES OF WRIST

DR. JAMES N. WORCESTER presented a man, thirty-one years of age. On July 11, 1927, while playing polo, horse fell, pinning the man's left arm underneath it. He was taken to the Greenwich Hospital where a röntgenograph showed fracture of both bones of forearm and of the scaphoid, with a dislocated semilunar. An attempt made under anaesthetic to reduce the fractures was partially successful, as far as the radius and ulna were concerned.

When seen by the reporter seven days after the accident, further X-rays revealed some slipping of radius and ulna and still dislocated scaphoid and semilunar.

At operation, July 19, 1927, the proximal portion of the scaphoid was found dislocated markedly anteriorly and two fragments were entirely loose. The distal portion of the scaphoid was fixed in its socket and also had several small fragments. The semilunar was displaced anteriorly and turned so that its articular surface faced directly forward. Radius showed over-riding of fragments with muscle in between. Through incision over the anterior surface of the scaphoid, the loose fragments were easily removed. Remainder of scaphoid removed with some difficulty. Attempt to replace semilunar was unsuccessful, so it was also easily removed. The anterior ligaments of the wrist-joint were repaired with interrupted sutures and the skin with silkworm and silk.

A second incision was then made over radius, fragments approximated and a Lane Plate with four screws applied. Soft parts closed. Anterior and posterior moulded splints applied reaching below the wrist. These were further shortened so as to give complete motion of the wrist-joint. Active motion to the wrist-joint was started immediately post-operative.

Splints were entirely removed end of four weeks. Active motion in wrist has gradually increased until at the present time the only limitation is a slight one of supination and pronation, which bothers him very slightly.

A large part of the success in this case was the coöperation of the patient for early motion is the one salvation, with or without operation. The cases Doctor Worcester had immobilized have had uniformly bad results.

CLINICAL AND PATHOLOGICAL CONSIDERATIONS IN SURGICAL DISEASE OF THE BILIARY TRACT

DR. WALTER A. SHERWOOD read a paper with the above title for which see page 178, *ANNALS OF SURGERY*, vol. lxxxviii.

BRIEF COMMUNICATIONS

CARCINOMA OF THE RECTUM AT EIGHTEEN YEARS OF AGE

THE majority of neoplastic diseases occur between the ages of forty-five and sixty years, especially those tumors involving the large bowel and rectum. The condition occurs rarely in younger individuals. There are cases reported in individuals under twenty years of age. The following case is deemed worthy of report, because of the youth of the patient.

A boy eighteen years of age was admitted to Saint Alexis Hospital in December, 1926, with the following complaint. Since September, 1926, he had had frequent attacks

of constipation. These attacks were transitory at first, and required no medication. The attacks of constipation became more frequent and lasted longer as time went on. Since November he had been constantly constipated and had resorted to cathartics in order to produce satisfactory bowel movements. Blood and mucus were occasionally found in the stools. During the six or eight weeks prior to his admission to the hospital, he complained of a dull ache in the lower part of the abdomen and in the rectum; this pain was greatly increased on moving the bowels. His first signs of weakness and loss of weight occurred about four weeks before his admission to the hospital. In all he had lost about twenty-five pounds. He complained of no other symptoms. The family history was negative for cancer. There was no history of injury nor of long continued irritation in or about the rectum. He had undergone no operations.

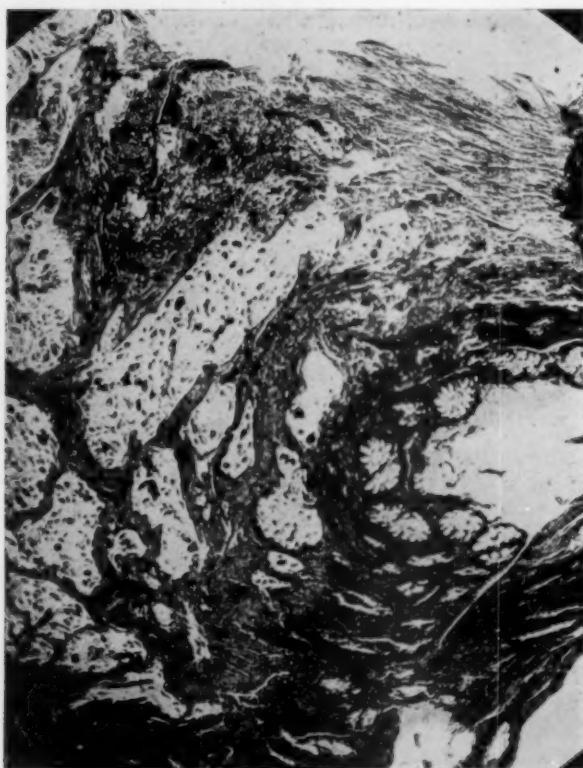


FIG. 1.—Low power. Section lined by tubular glands, well defined; submucosa and muscle wall diffusely infiltrated with large cell nests undergoing mucoid changes.

Physical examination revealed a fairly well developed and slightly emaciated male. The general physical examination did not reveal anything remarkable. There were no palpable masses in the abdomen and there was no protrusion from the rectum. On digital examination of the rectum a hard mass was encountered at the tip of the examining finger, this mass encroached upon the bowel to such an extent that the lumen was scarcely larger than a lead pencil. The tumor mass was hard, irregular and moderately fixed. It was painless and about the size of a lemon. It did not bleed readily, as no hemorrhage occurred

CARCINOMA OF THE RECTUM

even after several examinations. The sphincteric control was not impaired. The spinal fluid examination showed a negative Wassermann. The blood Wassermann was negative.

On December 21, 1926, the boy was operated upon. The abdomen was entered through a lower left rectus incision. The mass was found at the juncture of the rectum and sigmoid. The greatest infiltration had occurred in the posterior wall of the rectum, where the tumor had attached itself to the surrounding tissues. On further examination, the sacral and lumbar glands were found to be involved. Because of this glandular involvement excision of the mass was not attempted. The first stage of a colostomy was then performed. A small section was removed for microscopic study. Eight radium needles were then inserted into the tumor mass from the anal orifice, and were left in position for eighteen hours. The colostomy was opened four days later with the actual cautery. The eight radium needles were again inserted at a five day interval, and were left in place for twenty-four hours. The report on the specimen was as follows: "A section of the rectum which shows the mucosa and adjacent submucosa to contain numerous glandular elements made up of poorly staining cells undergoing colloid degeneration. These appear in occasional nests and also involving the surrounding deeper structure. Diagnosis, colloid carcinoma of the rectum." The colostomy functioned fairly well during his stay in the hospital. He was removed from the hospital January 1, 1927,

much against our wishes. The boy failed rapidly and expired June 22, 1927, six months after admission to the hospital and nine to ten months after his first symptoms had appeared. There was no autopsy.



FIG. 2.—High power. Section of shell nests showing poorly preserved cells which have lost their staining properties and are undergoing marked mucinaginous changes. Diagnosis: Colloid carcinoma of rectum.

The rarity of malignant disease in the rectum of children is readily seen by a review of the literature. One of the earliest cases reported is that of Steiner,¹ who reported a case in a boy nine years of age. Steiner quotes Henig² as saying that the condition occurs about once in 2,000,000 children. The classical and often quoted case of the Allinghams³ was in a boy thirteen years of age. Phillips⁴ a German author collected all cases up to 1908. Warthin⁵ at the University of Michigan found but two cases under thirty years of age in 2,000 specimens. Pennington⁶ in 7174 cases found forty occurring under twenty years of age. Fowler⁷ quoting Mayo Clinic statistics reported

BRIEF COMMUNICATIONS

fourteen cases in ten years. Clark⁸ late in 1926, reviewed all cases up to that time, and found that there were fifty-one to which he added one of his own.

The etiology of cancer occurring in young individuals is just as obscure as that occurring in adults. Trauma or long-continued irritation is often given as an etiological factor. If such a history can be obtained it will at least serve to draw attention to the affected part, which ordinarily would escape observation. The large amount of lymphoid tissue occurring in youth is thought by some to be a cause of adeno-carcinoma.

This case is reported through the courtesy of Dr. F. J. Schmoldt. Since this report has been prepared a similar case occurring in an eighteen-year-old boy is reported by S. A. Loewenberg in the *Med. Jour. and Record*, vol. cxxvii, p. 183, 1928, New York.

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CONGENITAL ABSENCE OF COLON

THE following report is that of a patient who represents one of the unusual types of colonic abnormalities, in that there was found to be absent the ascending transverse and descending colon, but there was present what appeared to be rudimentary cæcum at the left iliac crest into which the small intestine emptied. At the junction of the ileum and rudimentary cæcum the appendix was found.

A patient thirty-one years old, was admitted to the Iowa Methodist Episcopal Hospital, complaining of pains in the back and lower left abdominal regions and a continuous pelvic uneasiness and general languor. Her appetite was fair, but she suffered from constipation. The menstruations were regular but accompanied by a passing of clots and severe pain. There was no history of fever or vomiting. The examination revealed a marked tenderness over the left iliac region and lower pelvic area. Pelvic examination disclosed a tender exaggerated retroverted uterus, seemingly firmly fixed in the abnormal position. The fornices were normal.

Under ether anæsthesia the abdomen was opened in the midline. Since the patient had made special request that her appendix be removed, the cæcum was sought for, but could not be located. In fact, no part of the colon could be found, while the retractors were in position and traction was being applied. All instruments were removed from the

PENETRATION OF LOCAL SUPERFICIAL FOCI

abdominal incision, and all parts permitted to fall back into their previous position. Then flat retractors were inserted beneath the edges of the incision and the abdominal wall was lifted up, and the appendix, about twice the normal diameter, 10 cm. long, was seen standing out rigidly and pointing downward and inward from what seemed to be a rudimentary cæcum which was continuous with the sigmoid, and as accurately as could be measured, it was located about 27 cm. above the anus. The terminus of the ileum was easily traced entering the larger gut at the angle of the cæcum and sigmoid.

The chronic inflamed appendix was removed with no difficulty in the usual manner. The retroverted uterus was brought up to the normal position and the round ligaments were shortened by the Baldy-Webster technic. The patient had a normal recovery and the results proved to be very satisfactory.

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PENETRATION OF LOCAL SUPERFICIAL FOCI OF INFECTION BY NEEDLE CARRYING CARBOLIC ACID

ON November 12, 1919, I read before the New York Surgical Society a paper entitled "An Original Method of Treating Boils" and in it described an original technic which I had been practicing for some time in the treatment of boils. In 1925 I read a second paper on this subject before that society. In this method I availed myself of three properties possessed by a 95 per cent. solution of carbolic acid: its power of producing local anæsthesia; its power of cauterizing tissue; its power as an antiseptic. The instrument is a needle with the usual blunt eye-end. The eye-end of the needle is dipped in the carbolic acid and gently touched to the focus of the boil. This will deposit a little of the carbolic acid. It may sting for a few seconds. Soon local anæsthesia supervenes. The eye-end of the needle, freshly dipped in the carbolic acid, is then gently pressed upon the tissues with insinuating and searching motions. The needle, eye-end first, will gradually advance through the cutis vera, along a path where the inflammation has made a track of less resistance. If the process is conducted in a leisurely manner, the carbolic acid has time to anæsthetize the tissues in advance of the needle and simultaneously to make the inflamed track yield by progressive cauterization. When a channel has been made through the cutis vera, the blunt end of the needle enters the abscess cavity. The pus now has a vent. By repeatedly dipping the eye-end of the needle in carbolic acid and re-introducing it, the abscess cavity is anæsthetized, cauterized and disinfected. In some cases a single treatment suffices, in others it will require repetition on two or more successive days. There is usually no visible scar. When I have finished with the carbolic acid, I swab the skin or mucosa with alcohol to wash away any carbolic acid from the surface.

When I read my paper in 1919, I had used my method in a large number of cases. Since then I have used it in a very much larger number of cases and for infections in new locations.

Puncture wounds on the sole of the foot made by stepping on up-turned nails I have treated by this technic, either after they had become somewhat inflamed, or at once as a prophylactic measure. The point of entry of the nail

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is touched with carbolic acid. Soon the eye-end of the needle is gently worked in. By using a rather large needle, following the lead of least resistance and proceeding slowly, I have been able, with very little pain, to carbolicize the whole track made by the nail and to feel a resistance showing that I had reached the end of the track. This treatment causes very little irritation afterward. The patient may be able to walk in comfort the next day.

I have treated by this method painful stings of bees or yellow-jackets where there was no evidence of infection, but great swelling and pain. In these cases the eye-end of a fine needle armed with carbolic acid was made to follow the sting track through the skin. There was prompt relief. It would seem as if the carbolic acid had destroyed the poison of the sting.

Where a wooden splinter had broken off in the flesh so that it could not be grasped for extraction, I have found that the eye-end of a fine needle armed with carbolic acid would find its way down alongside the fragment of splinter and loosen the tissues by cauterization until the bit of wood could be worked out by the blunt end of the needle.

In an early case of acute paronychia, where there was as yet no indication as to where pus might appear below the skin, I applied carbolic acid at the border of the nail proximally and worked the eye-end of a needle down in it gently for some minutes. The blunt end of the needle advanced and entered a tiny cavity beneath the edge of the nail and a drop of pus exuded. No pus appeared subsequently and in a few days all inflammation was gone.

By a modification of this method, using alternately the eye-end and the point-end of a needle, I have demonstrated that an opening can be made through the sound skin into the subcutaneous tissue with hardly any pain.

I advocate this method as having a very wide application in infections and in some other conditions, giving in most cases where it is applicable quick destruction of infection, very little discomfort to the patient, no incision to heal and usually no perceptible scar.

The judgment of the surgeon will decide in what cases he may use this method and in what cases more radical measures are called for.

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